REVISED DRAFT

Smoky Canyon Mine
Remedial Investigation/Feasibility Study

Feasibility Study Technical Memorandum #1: Development and Screening of Remedial Alternatives

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ACAP	Alternative Cover Assessment Program
AMSL	Above Mean Sea Level
AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirement
BIA	Bureau of Indian Affairs
BLM	United States Department of Interior Bureau of Land Management
BMP	Best Management Practice
BOD	Biological Oxygen Demand
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm/s	centimeters per second
CO	Consent Order
COD	Chemical Oxygen Demand
COC	Chemical of Concern
COPC	Chemical of Potential Concern
CSM	Conceptual Site Model
DEIS	Draft Environmental Impact Statement
EA	Environmental Assessment
EC	Exposure Concentration
ECOC	Ecological Chemical of Concern
EE/CA	Engineering Evaluation/Cost Analysis
EIS	Environmental Impact Statement
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ET	Evapotranspiration
FEIS	Final Environmental Impact Statement
FWS	United States Department of Interior Fish and Wildlife Service
GCL	Geosynthetic Clay Liner
GCLL	Geosynthetic Clay Laminate Liner
GM	Geomembrane
gpm	gallons per minute
GRA	General Response Action
HH COC	Human Health Chemical of Concern
IDEQ	Idaho Department of Environmental Quality
IDFG	Idaho department of Fish and Game
IMA	Idaho Mining Association
MCL	Maximum Contaminant Level
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/kg dw	milligrams per kilogram dry weight
mg/L	milligrams per liter
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NTCRA	Non-Time-Critical Removal Action
ODA	Overburden Disposal Area
O&M	Operations and Maintenance
PRG	Preliminary Remediation Goal

QA/QC	Quality Assurance/Quality Control
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
ROM	Run-of-Mine
SAP	Sampling and Analysis Plan
SEIS	Supplemental Environmental Impact Statement
SeWG	Selenium Working Group
SI	Site Investigation
Simplot	J.R. Simplot Company
SSERA	Site-Specific Ecological Risk Assessment
SSHHRA	Site Specific Human Health Risk Assessment
SSLRA	Site-Specific Livestock Risk Assessment
SSSC	Site-Specific Selenium Criterion
SOW	Statement of Work
SUP	Special-Use Permit
TBC	To Be Considered
TCLP	Toxicity Characteristic Leaching Procedure
T/E	Threatened and Endangered
Tribes	Shoshone-Bannock Tribes
TRV	Toxicity Reference Value
USC	United Stated Code
USEPA	United States Environmental Protection Agency
USFS	United States Department of Agriculture Forest Service
USGS	United Stated Geological Survey
USMMS	United States Minerals Management Service
WDEQ	Wyoming Department of Environmental Quality

1.0 INTRODUCTION

The J.R. Simplot Company (Simplot) operates the Smoky Canyon Phosphate Mine (the Site) in southeast Idaho (Figure 1-1). The Smoky Canyon Mine is the subject of an Administrative Settlement Agreement and Order on Consent/Consent Order (Settlement Agreement/CO) for Performance of Remedial Investigation and Feasibility Study (RI/FS) entered into by the United States Department of Agriculture, Forest Service Region 4 (Forest Service [USFS]), United States Environmental Protection Agency, Region 10 (USEPA), Idaho Department of Environmental Quality (IDEQ), and Simplot (USFS, USEPA, and IDEQ 2009), pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Forest Service is the lead agency, and the USEPA, IDEQ, United States Department of Interior Fish and Wildlife Service (FWS) and Bureau of Land Management (BLM), and the Shoshone-Bannock Tribes (Tribes) participate as support agencies.

The Settlement Agreement/CO provides a mechanism to investigate the potential environmental effects of phosphate mining and milling operations at the Site and develop remedies to address any environmental conditions that represent a risk to human health or the environment. Section 4.1 of the Settlement Agreement/CO (USFS, USEPA, and IDEQ 2009), defines the “Site” as “the Smoky Canyon Phosphate Mine, which includes the areas of overburden disposal associated with the mine…the areal extent of contamination from the mine and overburden disposal areas and all suitable areas in very close proximity to the contamination necessary for response action implementation.” The Settlement Agreement/CO supersedes that portion of the 2003 Administrative Order on Consent/Consent Order (AOC/CO; IDEQ, USFS, and USEPA 2003) associated with the Smoky Canyon Phosphate Mine (Area A), but does not address the Tailings Impoundments (Area B). The 2003 AOC/CO remains in force with respect to Area B.

The general objective of the RI, as stated in the Settlement Agreement/CO (USFS, USEPA, and IDEQ 2009), is to determine the nature and extent of contamination and any threat to the public health, welfare, or the environment caused by the release or threatened release of hazardous substances, pollutants, or contaminants at or from the site, and to assess risks to human health and the environment. Data collection under the RI site characterization effort was performed from spring 2010 through fall/winter 2012/2013 in accordance with the scope of work presented in the RI/FS Work Plan (Formation 2011a) and sampling procedures and locations described in the Sampling and Analysis Plan (SAP) (Formation 2010) and SAP Addenda 01 through 04 (Formation 2011d, 2011e, 2012b, 2012c). The findings of the investigation, including physical site characteristics, nature and extent of contamination, and fate and transport of chemicals of potential concern (COPCs), were detailed in the RI Report (Formation 2014c).

Three separate baseline risk assessments, a Site-Specific Human Health Risk Assessment (SSHHRA, Formation 2015a), Site-Specific Ecological Risk Assessment (SSERA, Formation 2015b), and Site-Specific Livestock Risk Assessment (SSLRA, Formation 2016a), were performed and reported following the RI site characterization. The methodology used in the SSHHRA was developed in conjunction with input from the regulatory agencies and was outlined in the SSHHRA Work Plan (Formation 2011b) and a technical memorandum that identified screening levels, exposure factors, and toxicity factors (SSHHRA Technical Memorandum, Formation 2013a). Similarly, for ecological receptors, the methodology used for the SSERA was presented in the SSERA Work Plan (Formation 2011c) and Baseline Problem Formulation (Formation 2013b). The approach used in the SSLRA was based on USEPA Ecological Risk Assessment (ERA) guidance (USEPA 1997, 1998) and is consistent with a screening-level risk assessment that allows for identification of COPCs that could be present at concentrations that are potentially toxic to livestock. Potential risks to human, ecological, and livestock receptors from exposure to contaminants at the Site were evaluated in these RAs.

The findings presented in the RI Report (Formation 2014c) and the risk assessments serve as the basis for identifying the Remedial Action Objectives (RAOs) for the Site and are used to support the development of remedial alternatives in this FS. The general objective of the FS, as stated in the Settlement Agreement/CO (USFS, USEPA, and IDEQ 2009), is to identify and evaluate alternatives for remedial action designed to prevent, mitigate, or otherwise respond to or remedy any release or threatened release of hazardous substances from the Site. The FS builds on the analyses presented in the Engineering Evaluation/Cost Analysis (EE/CA) (NewFields 2006), which identified and evaluated a range of removal action alternatives to address unacceptable environmental conditions identified through the Site Investigation (SI) (NewFields 2005a).

1.1 Purpose

Per the Settlement Agreement/CO and subsequent correspondence, the FS report has been divided into two components, which will be submitted as two separate deliverables (1) the development and screening of remedial alternatives and (2) the detailed analysis of alternatives. The purpose of Technical Memorandum #1, which is the first component of the FS process, is to identify and screen a range of remedial alternatives to be evaluated in the detailed analysis. This technical memorandum includes the elements set out in Section 8.a. of the Statement of Work (SOW) and has been prepared in accordance with USEPA Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA 1988).

Alternatives are developed by assembling combinations of technologies for specific environmental media that address contamination on a Sitewide basis or for specific overburden disposal areas (ODAs). Alternatives retained for further consideration and analysis will be refined and analyzed in detail with respect to the evaluation criteria in the detailed analysis. The results of the detailed analysis of alternatives will be documented in Technical Memorandum #2, due 90 days after submittal of the Phase 2 Water Treatment Pilot Study Report. These two FS components will comprise the draft FS Report.

1.2 Site Location and Description

The Smoky Canyon Mine is located in Caribou County, Idaho (Figure 1-1), within the Southeast Idaho Phosphate Mining Resource Area. The mine is located approximately 24 miles due east of Soda Springs, Idaho and is accessed by traveling approximately 10 miles generally west from Afton, Wyoming. The mining and milling operations are contained within 2,600 acres of federal phosphate mineral leases (Federal Phosphate Leases No. I-012890, I-026843, I-027801, I-27512, and I-30369) administered by the Pocatello Field Office of the BLM and approximately 1,200 acres of Special Use Permit (SUP) administered by the Caribou-Targhee National Forest. Phosphate ore is extracted from a series of pits, referred to as mine panels, located on the eastern slope of the Webster Range between Smoky Canyon and South Fork Sage Creek (Figure 1-2). Specific mining and mine-related areas of the Site addressed in this FS include backfilled Panels A, B, C, D, and E; the external ODAs associated with these mine panels; and the Pole Canyon cross-valley fill ODA (Figure 1-3).

The mill and administrative and maintenance facilities are located in Smoky Canyon near the northern end of the mining operations. Mine Panel A is located immediately east of the mill, Panels B and C are north of the mill, and Panels D and E and the Pole Canyon ODA are south of the mill. The tailings ponds, which are not included within the Site as defined by the 2009 Settlement Agreement/CO, are located about 3 miles northeast of the mill in the Tygee Creek drainage on 1,680 acres of private land owned by Simplot. The mill is connected to the tailings ponds by a pipeline that extends down Smoky Canyon.

Mining activities began at Smoky Canyon in 1983 and are ongoing today. Ore is recovered through open pit mining practices which follow the north-south trending Phosphoria Formation outcrop as it dips to the west. Ore is recovered until the amount of overburden that must be removed to expose the ore (stripping ratio) becomes uneconomical. The overburden, which consists of Dinwoody, chert, limestone, and center waste shale, is used to backfill the previously mined pits and has also been placed in external ODAs just east of the pits to maintain efficient material balance as mining has progressed. Reclamation practices have changed over time, in response to the developing understanding of environmental conditions associated with releases from the overburden. Current practices entail grading to a 3:1 slope, placement of a cover, application of seed and fertilizer, and sometimes planting of shrubs and trees.

1.3 Investigations and Current Site Status

Previous investigations conducted at the Smoky Canyon Mine are described in detail in the RI Report (Formation 2014c) and include the following:

- 1981 Draft Environmental Impact Statement (EIS) – The United States Geological Survey (USGS), then in charge of administering phosphate mining on federal lands, prepared a Draft EIS (DEIS) for mining at Smoky Canyon in conjunction with the Forest

Service (USFS and USGS 1981). The DEIS evaluated potential environmental impacts associated with the Smoky Canyon Project Mine and Reclamation Plan, submitted by Simplot in February 1981 (Simplot 1981).

- 1982 Final Environmental Impact Statement – The Final EIS (FEIS) was completed in 1982 (USFS and United States Minerals Management Service [USMMS] 1982), and the approval letter for the Project Mine and Reclamation Plan was signed in January 1983 (BLM 1983).
- 1990s Environmental Assessments (EAs) for Smoky Canyon Mine – Plans for individual mine phases were submitted to the regulatory agencies for review and approval (Panel A-4, BLM 1991; Panel D, BLM and USFS 1992; Panel E, BLM 1997).
- Mid-1990s Idaho Mining Association (IMA) Selenium Committee – The primary mine operators in the region formed the IMA Selenium Committee in order to jointly and voluntarily investigate and address mining-related environmental and public health issues associated with past operations.
- 2000 Area-Wide Administrative Order on Consent (AOC) – The AOC established the process used to conduct investigations and characterize risks associated with former and active mining at an “Area-Wide” scale (IDEQ, USEPA, USFS, BLM, FWS, Bureau of Indian Affairs [BIA], and Tribes 2000).
- 2002 Panels B and C Supplemental EIS – A Supplemental EIS (SEIS) (BLM and USFS 2002) was conducted for the Smoky Canyon Mine Panels B and C areas to evaluate potential environmental impacts related to selenium releases and to establish new mitigation measures as needed to address these impacts. The Record of Decision (ROD) for Panels B and C was signed in 2002 (BLM 2002).
- 2002 Panels B and C Consent Order – A Consent Order was developed by IDEQ and Simplot for the protection of groundwater during Panels B and C mining activities (IDEQ 2002). The 2002 Consent Order provides for compliance with the Idaho Ground Water Quality Rule and also established a number of new monitoring requirements that are specific to the Panels B and C operations.
- 2003 Administrative Order on Consent/Consent Order (AOC/CO) – Simplot entered into an AOC/CO with IDEQ, USFS, BLM, and USEPA to evaluate and address the cumulative environmental and human health risks from current and historical mining operations at Smoky Canyon (IDEQ, USFS, and USEPA 2003). The 2003 AOC/CO established the responsibilities and schedules for performance of an SI and EE/CA for the Smoky Canyon Phosphate Mine (Area A) and other necessary actions associated with the Tailings Impoundments (Area B) (NewFields 2005a, 2006).
- 2006 Settlement Agreement for Non-Time-Critical Removal Action (NTCRA) for the Pole Canyon ODA – Based on information provided in the SI and EE/CA, the Forest Service selected an NTCRA to address conditions associated with the Pole Canyon cross-valley fill ODA. In October 2006, Simplot entered into a Settlement Agreement with the Forest Service, USEPA, and IDEQ to implement the Pole Canyon 2006 NTCRA (USFS, USEPA, and IDEQ 2006).

- 2009 Administrative Settlement Agreement/CO for RI/FS – Simplot entered into a Settlement Agreement/CO for performance of an RI/FS for the Smoky Canyon Mine, including Panel B where mining is currently active (USFS, USEPA, IDEQ and 2009). The RI site characterization and baseline risk assessments have been completed.
- 2012 EE/CA for NTCRA Alternatives at Pole Canyon ODA – An EE/CA was completed in 2012 (Formation 2012a) to identify and evaluate NTCRA alternatives that address conditions at the Pole Canyon ODA. Based on the EE/CA, the Forest Service selected a Dinwoody/Chert cover.
- 2013 Settlement Agreement for NTCRA for the Pole Canyon ODA – The Forest Service issued an Action Memorandum (USFS 2013a) to document approval of a Dinwoody/Chert cover for the Pole Canyon ODA as a Removal Action. The Dinwoody/Chert cover NTCRA was implemented under a separate Settlement Agreement for NTCRA entered into by the Forest Service, IDEQ, the Tribes, and Simplot in November 2013 (USFS, IDEQ, and Tribes 2013).

1.4 Document Organization

This technical memorandum is organized as follows:

- Section 2 summarizes information from the RI Report and the risk assessments, including physical characteristics, mining and reclamation status, nature and extent of contamination, contaminant fate and transport, and potential risks to human, ecological, and livestock receptors.
- Section 3 summarizes the environmental conditions of concern and presents Applicable and/or Relevant and Appropriate Requirements (ARARs), RAOs, and Preliminary Remediation Goals (PRGs).
- Section 4 identifies the General Response Actions (GRAs), remedial technologies, and process options potentially implementable to address the RAOs and describes the initial screening and evaluation process.
- Section 5 presents and describes the remedial alternatives assembled and describes the screening evaluation of these alternatives.
- Section 6 lists references and data sources that were used to develop this technical memorandum.

2.0 SUMMARY OF SITE CHARACTERISTICS AND RISKS

This section presents a summary of the conceptual site model (CSM) and site characterization information presented in the RI Report (Formation 2014c) and the risk evaluations presented in the SSHHRA (Formation 2015a), SSERA (Formation 2015b), and SSLRA (Formation 2016a). The focus of this summary is on the important physical and chemical characteristics and transport and exposure pathways relative to remedial alternative development and evaluation. Selenium is the primary contaminant in both solids/soil and groundwater/surface water and is the primary risk driver for human, ecological, and livestock receptors. The elevated concentrations of other COPCs coincided with selenium exposures in most cases. Therefore, the discussion in this section focuses on selenium, although when other COPCs are above levels of concern they are also noted.

2.1 Site Setting and Physical Characteristics

The Smoky Canyon Mine is located along the eastern slope of the north-south trending Webster Range just west of Sage Valley. Phosphate ore is extracted from the Phosphoria Formation in a series of pits between Smoky Canyon and South Fork Sage Creek that extend (north to south) for a distance of approximately 6 miles (Figure 1-2). Elevations at the Site range from 6,500 to 8,300 feet above mean sea level (AMSL). Information on the physical characteristics of the Site and surrounding areas has been collected to support the evaluation of the nature and extent of contamination, define potential contaminant transport pathways, and identify receptor populations.

2.1.1 Climate

The area in the vicinity of the Smoky Canyon Mine has a cool and dry climate, with typical prevailing winds and weather patterns moving from west to east. Annual precipitation of 14 to 28 inches has been measured at the Security Building at the mine, with the most abundant rainfall occurring in spring and early summer. In the winter months, snowfall averages 100 inches per year, and snow cover typically remains on the ground from November to April. Summer temperatures in the region normally range from 48 to 62 degrees Fahrenheit, while winter temperatures typically range from 12 to 26 degrees Fahrenheit.

2.1.2 Land Use

Much of the Smoky Canyon Mine is on National Forest System land, including the lease areas where mining takes place. Private ranch land owned by Simplot is located in Sage Valley immediately east of the mine panels. Other private lands (ranches and vacation homes) are located in the Crow Creek Valley south and southeast of the Site. The predominant land uses are associated with agriculture and natural resources, and include crop production (primarily hay) on private lands along with cattle and sheep ranching on private and public lands. Phosphate mining, while not a dominant land use in terms of acreage, is economically important. On National Forest System land, recreational activities include hunting, fishing, camping, hiking, skiing, and snowmobiling, among others. Additionally, these lands may be used for Tribal hunting, fishing, and ceremonial activities consistent with their heritage. No residential use occurs at or adjacent to the Site. The closest population center is the Star Valley community, which includes the town of Afton, Wyoming, and is approximately 10 miles directly east of the Site. The town of Afton has a population of approximately 1,800 (United States Census Bureau 2010).

2.1.3 Geology

The Smoky Canyon Mine is in the Idaho-Wyoming thrust belt and is underlain by the westward-dipping Meade thrust fault (Ralston and Mayo 1983). Movement on the thrust fault was from west to east. Strata within the thrust plate were folded into a series of north-south-trending anticlines and synclines that have been eroded into a series of ridges and valleys. Steep eastward-trending tear faults that developed during thrusting form small canyons dissecting these ridges (Armstrong and Cressman 1963). The mine is located on the west limb of the Boulder Creek Anticline, which is a north-south-trending, north-plunging fold. Figure 2-1 presents a geologic map of the Smoky Canyon Mine area compiled from Montgomery and Cheney (1967) and Connor (1980). Figure 2-2 provides an explanation of the map units. The anticline is truncated on the east by the West Sage Valley Branch Fault, which is an imbricate thrust of the Meade thrust fault (Mayo et al. 1985), and is a barrier to eastward groundwater flow. Thrusting along the fault has displaced older, highly fractured rocks on the west side of the fault against younger relatively lower hydraulic conductivity rocks on the east side.

Sandstone and limestone of the Pennsylvanian/Permian Wells Formation forms the core of the Boulder Creek Anticline. The Wells Formation is overlain by the Permian Phosphoria Formation, which is exposed primarily along the west limb. The Phosphoria is the source of phosphate ore for the mine and is comprised of three members: the Meade Peak Phosphatic Shale Member, Rex Chert Member, and Cherty Shale Member. Seleniferous shale and chert are the primary types of overburden (i.e., run-of-mine [ROM] material) that are removed in order to access the ore. The overlying Triassic Dinwoody/Thaynes formations are composed of shale, siltstone, and limestone, and are exposed west of the mine within the Webster Syncline, north of the mine where the anticline plunges into the subsurface, and east of the mine in Sage Valley. Bedrock in the valley is overlain by silty limestones of the Tertiary Salt Lake Formation and Quaternary sediments. Colluvial gravel and sand form fan-shaped deposits in South Fork Sage Creek, Sage Creek, and Pole Canyon Creek where the creeks emerge from the foothills and flow into Sage

Valley. Alluvial sand and gravel is deposited by North Fork Sage Creek on the floor of Sage Valley.

2.1.4 Groundwater

Groundwater occurs in two aquifer systems at the Smoky Canyon Mine (1) the shallow alluvial groundwater system and (2) the deep Wells Formation aquifer.

The shallow alluvial groundwater system consists of thin, narrow, unconsolidated, surface deposits that are locally present along the natural stream channels that transect the mine area, and receive recharge from the surface at and in the vicinity of the Site. Along the west side of Sage Valley, these local stream channel deposits transition to much thicker and laterally extensive colluvial and alluvial deposits that cover the floor of northern Sage Valley and fill in between bedrock highs in lower Sage Valley (Figure 2-1). The valley-fill aquifer discharges to Sage Creek along several stream segments.

Regional groundwater flow in the deep Wells Formation aquifer is controlled by (1) the elevation of recharge areas on Freeman Ridge and Dry Ridge to the west and Meade Peak to the south (see locations on Figure 1-1), (2) the elevations of two major discharges from the aquifer—Hoopes Spring and South Fork Sage Creek springs—located east of Panel E (see spring locations on Figure 2-1), and (3) the effects of local structural features such as the West Sage Valley Branch Fault. The Wells Formation aquifer receives local recharge from precipitation in outcrop areas along the Boulder Creek Anticline and infiltration from streams crossing outcrop areas (Figure 2-1). In the vicinity of the Site, streams flowing eastward generally gain flow as they cross the Dinwoody outcrop west of the mine, remain constant in terms of flow across the Phosphoria Formation, and then lose flow as they cross the Wells Formation outcrop.

Most of the backfilled pits and ODAs at the mine overlie Wells Formation outcrops/subcrops. The Wells Formation aquifer lies several hundred feet or more below the backfilled pits and ODAs and is separated from them by unsaturated Wells Formation limestone. Groundwater elevations exhibit seasonal fluctuations. Except for the Wells Formation groundwater captured by the Industrial Well (GW-IW), Site groundwater within the Wells Formation aquifer generally flows to the east and south. Groundwater flow in the upper Wells Formation aquifer is controlled by the combined effects of the West Sage Valley Branch Fault, which is a barrier to flow to the east, and the discharge zone created by Hoopes Spring and South Fork Sage Creek springs (the “springs complex”). Discharge from the springs complex comprises the majority of flow in the lower Sage Creek drainage under all flow conditions. The springs complex creates a capture zone that prevents groundwater flow to the south. Figure 2-3 is a potentiometric map which shows groundwater flow directions under current conditions during pumping at the Industrial Well (GW-IW). The flow directions and gradients vary seasonally.

2.1.5 Surface Water

The slopes of the Smoky Canyon Mine generally drain eastward with streams flowing into the Salt River, which joins the Snake River and ultimately the Columbia River. Surface water at the Site occurs within two drainage basins: the Tygee Creek basin in the north end of the Site and the Sage Creek basin in the south end (Figure 2-4).

The Tygee Creek basin includes the drainages of Smoky Creek, Roberts Creek, and Lower Tygee Creek and drains to Stump Creek. Draney Creek and Webster Creek are also within the Tygee Creek drainage basin north of the Site. Panels B and C and the northern portion of Panel A are located in the Tygee Creek basin. Smoky Creek crosses mine-disturbance areas in Panel A but does not receive runoff from these areas. Surface runoff from Panel A is diverted to stormwater detention basins. Data collected during the RI showed that no water was discharged from the detention basins in the Panel A area (Formation 2014c).

The Sage Creek basin includes the drainages of North Fork Sage Creek, Pole Canyon Creek, Sage Creek, and South Fork Sage Creek and drains to Crow Creek. Panels D and E, the Pole Canyon ODA, and the southern portion of Panel A are located within the Sage Creek basin. Pole Canyon Creek, Sage Creek, and South Fork Sage Creek cross these mine panels but do not receive runoff from these mine-disturbance areas. However, certain creeks do receive groundwater discharged from either the alluvial flow system or the Wells Formation aquifer. Lower Pole Canyon Creek flows into Sage Valley, but generally loses flow to the alluvial groundwater system before reaching North Fork Sage Creek. Wells Formation groundwater that discharges at Hoopes Spring and South Fork Sage Creek springs continues downstream into Sage Creek and South Fork Sage Creek. Sage Creek flow typically remains constant through lower Sage Valley and into the Crow Creek drainage.

2.1.6 Ecology

Several vegetation or habitat types have been identified within and around the Smoky Canyon Mine (Maxim 2002). Higher elevation areas and north- and west-facing slopes receive sufficient moisture to support subalpine fir and Engelmann spruce, and mid-elevation areas are represented by Douglas-fir and aspen. Forest openings are dominated by a mixed shrub component that includes mountain snowberry and antelope bitterbrush. The warmer and drier lower elevation areas and south-facing slopes are typified by mixed shrub communities of sagebrush and various grassland species. Riparian areas are dominated by willows, sedges, and reedgrass, and watercress is commonly found at Hoopes Spring and in Sage Creek.

The diverse vegetation types found at the Site provide habitat for a variety of wildlife species (BLM and USFS 2002). Mammals include bats, rabbits, rodents, black bear, mountain lion, mule deer, elk, and moose. Numerous bird species occur in the area, including raptors, passerines, waterfowl, and shorebirds. Game birds such as grouse are also common. Cutthroat trout, brook trout, rainbow trout, brown trout, dace, sculpin, redside shiner, chub, and a wide variety of macroinvertebrates have been documented in area streams. Amphibian and reptile species known to occur at the Site include tiger salamander, rubber boa, and western terrestrial garter snake.

The only federally-listed threatened and endangered (T/E) species in Caribou County is the Canada lynx (*Lynx canadensis*) (FWS 2013). Although potential “linkage” habitat for the lynx is present (Ruediger et al. 2000; USFS 2007), surveys for lynx indicate that this species is not present in the Smoky Canyon Mine area (Maxim 2002, 2004; BLM and USFS 2007). The same habitat is also potentially suitable for the gray wolf (*Canis lupus*). In May 2011, the FWS published a direct final rule delisting wolves in Idaho (FWS 2011).

2.1.7 Status of Mining and Reclamation

The progression of mining and reclamation at the Smoky Canyon Mine is presented in appendices to the RI Report (Formation 2014c), and is based on maps prepared from mine disturbance and reclamation data, elevation information, aerial images, and panel chronology. The current status of mining and reclamation in the mine panels (Figure 1-3) are as follows (using approximate mine panel and ODA reclamation areas listed in the RI Report):

- <u>Panel A and External ODAs</u> - Panel A covers approximately 245 acres; the external ODAs cover 135 acres. Pits A-1, A-2, and A-3 were backfilled shortly after mining and covered with topsoil or reclaimed by direct revegetation. Pit A-3 is partially regraded and will be backfilled and reclaimed as part of ongoing mining operations in Panel B.
- <u>Panel B and External ODA</u> - As of fall 2012, Panel B covers approximately 155 acres; the external ODA covers approximately 50 acres. Reclamation activities for the external ODA and the lower portion of Pit B-1 have been completed with a topsoil over chert cover. Mining is continuing in Pits B-2 and B-4.
- <u>Panel C</u> - Panel C covers approximately 105 acres and was mined from 2002 through 2006. Panel C is backfilled with overburden from Panels B and C. The northern end of Panel C (approximately 45 acres) was reclaimed in 2008 and the remainder of Panel C was reclaimed in 2010 with a topsoil-over-chert cover.
- <u>Panel D and External ODA</u> - Panel D covers approximately 270 acres; the external ODA covers 90 acres. Mining at Panel D took place from 1993 through 1998 in three pits (Pits D-1, D-2, and D-3). Panel D overburden was placed in an external ODA as well as in portions of the Pole Canyon ODA. The pits and overburden areas were reclaimed in 2002 by direct revegetation or covered with topsoil only or topsoil over chert.
- <u>Panel E and External ODA</u> - Panel E contains a total of five pits (Pits E-0, E-1n, E-1s, E-2, and E-3) and covers approximately 390 acres; the external ODA covers 120 acres. Mining in Panel E began in 1998 in Pit E-1n and continued through 2006. Reclamation of this pit and the external ODA was completed in 2003 with topsoil-over-chert or a Dinwoody/Chert cover. Mining began in the other pits in Panel E in 2000 and 2001.

Backfilling of Pits E-2 and E-3 began in 2003. Pits E-1s, E-2, and E-3 were reclaimed with a Dinwoody/Chert cover in 2008. Pit E-0 was backfilled with overburden from Panel F in 2010. Pit E-0 was covered with the Deep Dinwoody cover system in 2014.

- Pole Canyon ODA - The Pole Canyon ODA is an external disposal area that covers approximately 130 acres in the Pole Canyon Creek drainage. The Pole Canyon ODA was constructed as a cross-valley fill over Pole Canyon Creek. Most of the overburden originated from Panel A, which was mined from 1985 to 1990. A much smaller portion of the overburden originated from Panel D (Pit D-2) and was placed on the west side of the ODA in 1997. Two NTCRAs were completed at the Pole Canyon ODA in 2008 and 2015, as discussed below.

A summary of reclamation areas and cover types is provided in Table 2-1.

2.1.8 Non-Time-Critical Removal Actions

Two NTCRAs have been completed at the Pole Canyon ODA. The first was implemented under a Settlement Agreement/CO (USFS, USEPA, and IDEQ 2006) to reduce the rate of selenium transport from the Pole Canyon ODA to the environment thereby improving downstream and downgradient water quality. This first NTCRA is referred to herein as the "2006 NTCRA." Construction of the 2006 NTCRA was completed in 2008 and entailed:

- A bypass pipeline to divert Pole Canyon Creek stream flow around the ODA and directly into Sage Valley;
- An infiltration basin that directs clean flow from Pole Canyon Creek in the area between the pipeline diversion inlet and the upstream toe of the ODA to the Wells Formation aquifer; and
- A channel to prevent run-on to the Pole Canyon ODA from the northern hillside slope.

The second NTCRA, referred to as the "2013 NTCRA," was implemented under a separate Settlement Agreement/CO entered into by the Forest Service, IDEQ, the Tribes, and Simplot in November 2013 (USFS, IDEQ, and Tribes 2013), to reduce or eliminate the amount of precipitation that infiltrates into the ODA, reduce or eliminate risks due to ingestion of vegetation and direct contact with ODA materials, and eliminate the release of contaminants from the ODA via sediment transport. Construction of the 2013 NTCRA was substantially completed in 2015 and included:

- Grading the surface of the ODA;
- Covering the ODA with chert/limestone averaging 2 feet in thickness overlain by 3 feet of Dinwoody material;
- Revegetating the Dinwoody surface with native non-selenium accumulating species; and
- Stormwater run-on/runoff controls to convey water off the ODA.

2.1.9 Pilot Studies

Per the RI/FS Settlement Agreement/CO (USFS, USEPA, and IDEQ 2009) requirements, Simplot prepared a technical memorandum to provide an evaluation of available water-treatment technologies and identify the technologies that appear most suitable for the Site (NewFields and Formation 2009). The likelihood for further evaluation of a technology through the FS process of remedial alternative development was determined based on the level of demonstrated effectiveness, commercial availability, use of resources, and overall ease of implementation at the Site. Based on the findings of the 2009 Surface Water Treatability Study Technical Memorandum, the following pilot studies have been implemented at the Site to evaluate the performance of technologies with the highest potential for use as remedial actions:

- 2009 – GE ABMet® active, anoxic/anaerobic, biological process – DS-7 seep and also at the nearby Conda Mine;
- 2009 – Zero-valent iron technology – South Fork Sage Creek;
- 2010 – Reverse osmosis – Hoopes Springs; and
- 2013 (ongoing) – Semi-passive biological treatment technology – DS-7 seep.

These treatment technologies are discussed in detail in an addendum (Formation 2014a) to the technical memorandum cited above. The major findings from these studies were as follows:

- Passive treatment of spring discharges by zero-valent iron technology is not effective in meeting the surface water quality criterion for selenium.
- Concentration by reverse osmosis is a viable option to concentrate contaminants for removal by other treatment technologies.
- Passive and semi-passive biological reduction treatment may be an option for seeps, which do not discharge into surface waters, and where significant removal of selenium (rather than meeting the surface water quality criterion for selenium) may be an appropriate goal.
- Active treatment by biological reduction is effective and can meet the surface water quality criterion for selenium. Biological oxygen demand (BOD) and chemical oxygen demand (COD) were monitored in the effluent discharged after treatment. Constituents added to the water stream as a result of treatment included ammonia, phosphorus, and total organic carbon. Temperature increased and pH and dissolved oxygen decreased in the effluent, compared to the influent. The required discharge limits depend on the setting of the system (i.e., discharging to surface water, mixing zones, upstream concentrations, etc.). The BOD/COD levels in the discharge need to be considered to evaluate the effect on dissolved oxygen levels in the receiving stream. Additional polishing of water quality is necessary before treated effluent can be discharged to nearby stream drainages, especially for larger-flow systems.

Two other pilot studies were implemented in 2005, prior to initiation of the RI/FS, at seeps associated with external ODAs to isolate seep water that wildlife and livestock may use as drinking water sources. One of the pilot studies was implemented at detention basin DP-10, which is adjacent to a haul road in Panel D. The study involved elimination of the basin by removal of the constructed berms and installation of a chert cover over the area (NewFields 2004a). Upon completion, the potential for wildlife contact with water in the DP-10 basin and/or associated vegetation immediately downslope of the basin was eliminated. Visual monitoring indicates that this measure has been effective in eliminating the potential for exposure.

The other pilot study was implemented to address water from snowmelt and stormwater emanating from the southwest toe of the Panel E ODA (seep ES-5) than flowed along the ground surface before infiltrating. Pilot study work included overburden recontouring to limit future discharge of seep water to the surface in the ES-5 area and placement of a chert cover over the ground surface where seep water flowed (NewFields 2004b). No flow from the ES-5 seep area has been observed after these actions were completed.

2.2 Nature and Extent of Contamination

The RI confirmed previous SI findings that overburden disposed in backfilled mine pits and external ODAs is the source of selenium and other COPCs to the environment. Overburden is removed during active mining to access the underlying phosphate ore. The primary sources of selenium and other COPCs within the overburden are the sulfides and organic matter present in the mudstone and center waste shale from the Meade Peak Member of the Phosphoria Formation. Selenium and other COPCs are released from overburden materials to infiltrating/percolating water. Transport to Wells Formation groundwater and discharge to surface water via Hoopes Spring and South Fork Sage Creek springs is considered the primary mechanism for transport of selenium to the environment.

The physical setting of the different backfilled pits and external ODAs at the Site and the type of reclamation completed on each influences the relative importance of these sources in terms of mass flux of selenium and other COPCs released and transported. Less protective covers (including direct revegetation) allow greater infiltration of precipitation resulting in larger contributions of selenium and other COPCs to the underlying groundwater. More recent Dinwoody/Chert covers are more effective in reducing infiltration. The Pole Canyon ODA is distinct from the other ODAs at the Site because of the cross-valley fill setting (with Pole Canyon Creek flowing through the ODA prior to the 2006 NTCRA) and the presence of an underlying shallow alluvial groundwater system associated with Pole Canyon Creek.

2.2.1 Soil and Vegetation

<u>Soil</u>

Selenium concentrations on the surface of ODAs with less protective covers are elevated due to the presence of seleniferous shale in the ROM overburden. There is no significant physical transport (i.e., erosion) of these materials at the Site. Thicker covers of topsoil or other geologic material generally result in lower concentrations of selenium at and near the surface. Reclamation areas and cover types for each of the mine panels are shown on Figure 1-3 and listed in Table 2-1. The highest mean selenium concentrations in soil were measured on Panel A Area 2 (topsoil cover), the Pole Canyon ODA prior to the 2013 NTCRA (no cover), Panel D South (topsoil-over-chert cover), and Panel D North (topsoil cover). The lowest mean selenium concentrations were measured on Panel A Area 1 (topsoil over Dinwoody/Chert cover), Panel E Area 1 (topsoil-over-chert cover), and Panel E Area 2 (topsoil over Dinwoody/Chert cover). The mean selenium concentration for soils sampled on Panel A Area 1 and Panel E was similar to the mean concentration for soils sampled in northern Sage Valley. Since the RI was completed in 2014, exposure to overburden material in soils on the Pole Canyon ODA has been addressed under the 2013 NTCRA (USFS, IDEQ, and Tribes 2013) with a Dinwoody/Chert cover, completed in 2015.

Selenium concentrations were generally low in soils adjacent to the ODAs, with exceptions in some of the seep areas. Sheet or rill erosion does not lead to widespread contamination of soils that are downgradient from the ODA source areas either during mining or shortly after mining is completed before reclamation occurs.

Surface transport of selenium from surface water to soil is limited to the immediate areas of overburden seepage and was not observed in northern Sage Valley, with the exception of elevated concentrations within a small occasionally wet area that may either periodically receive surface water flow from Pole Canyon Creek or exhibit periodic expressions of shallow groundwater.

Vegetation

Terrestrial vegetation was collected at many of the same locations where soil samples were collected including vegetation growing on ODAs and in adjacent area soils. Uptake of selenium by vegetation growing on ODAs with less protective covers was identified as a potential exposure pathway for ecological receptors specifically in the Panel A Area 2, Pole Canyon ODA (prior to the 2013 NTCRA), Panel D South, and Panel D North areas. Plant uptake of selenium also occurs in soils that are saturated with water originating from overburden seeps, with localized effects of seeps on selenium concentrations in vegetation focused on vegetation where the root zone is consistently saturated with seep water. Selenium concentrations in vegetation are generally correlated with selenium concentrations in the soil, with greater variability at higher concentrations. Selenium concentrations in vegetation are lower when the mine pit or ODA has been reclaimed using a more protective cover system, such as the Dinwoody/Chert cover which has been constructed on Panel E. Elevated concentrations of arsenic are present in vegetation where overburden is at the surface, and this was identified as posing a potentially unacceptable risk to human receptors consuming beef grazing in these areas.

Selenium accumulation into plants is of particular interest at the Site. Based on surveys conducted during site characterization for the RI, selenium hyperaccumulator (e.g., *Astragulus*) and accumulator (e.g., *Aster*) plant species are absent from much of the Site which may be due in part to an herbicide program. None of the species listed by Mackowiak and Amacher (2010) as hyperaccumulators (plants accumulating selenium at concentrations greater than 500 mg/kg) or accumulators (plants accumulating selenium at concentrations from 50 to 100 mg/kg) were observed in any of the transect locations nor in any of the composite samples collected for the RI (Formation 2014c). However, alfalfa (*Medicago sativa*) is common in some of the reclaimed areas of the Site and elsewhere in the region, and is considered a selenium accumulator in some investigations.

2.2.2 Wells Formation and Alluvial Groundwater

Exceedances of the Maximum Contaminant Level (MCL), also the Idaho drinking water standard, of 0.05 milligrams per liter (mg/L) for selenium were observed in Wells Formation groundwater and alluvial groundwater downgradient of source areas, for example, at several wells immediately downgradient of the Pole Canyon ODA. However, selenium concentrations in groundwater from all other locations were lower than the drinking water standard. These wells downgradient of the Pole Canyon ODA also contained arsenic concentrations that exceeded the drinking water standard (0.01 mg/L), and are known to be affected by past infiltration of water into the ODA, and downgradient transport in alluvial and Wells Formation groundwater.

<u>Wells Formation Groundwater</u>

Specifically for the Wells Formation groundwater aquifer, selenium is present above the 0.05 mg/L groundwater MCL downgradient of source areas (at the Industrial Well and for monitoring wells GW-16 and GW-25), and above the State of Idaho Surface Water Quality Criterion for Aquatic Life of 5 micrograms per liter (µg/L) where groundwater discharges to surface water at Hoopes Spring and South Fork Sage Creek springs. Selenium concentrations in the springs have been increasing recently, with individual measurements within the springs complex over the past couple of years ranging from approximately 0.03 to 0.13 mg/L (Hoopes Spring) and from less than 0.01 to 0.08 mg/L (South Fork Sage Creek springs).

In the Panels A and C area, samples collected at the Industrial Well since the early 2000s indicate a slowly increasing baseline selenium concentration and a pattern of concentration spikes that typically occur in the middle of the calendar year, during late spring and early summer recharge conditions. The total selenium concentration in the Industrial Well reached a high of 0.126 mg/L in the sample collected in June 2011, but the concentration has remained at approximately 0.03 mg/L since then.

For Wells Formation groundwater, exceedances of groundwater MCLs for non-selenium COPCs were observed for aluminum, arsenic, iron, and manganese for some of the samples collected at several of the monitoring wells. However, these exceedances were not as consistent as those identified for selenium in Wells Formation groundwater and were typically co-located with elevated selenium concentrations.

Alluvial Groundwater

The Pole Canyon ODA is the only source area that contributes water to the alluvial groundwater flow system. Selenium concentrations are highest in shallow groundwater immediately downgradient of the Pole Canyon ODA adjacent to lower Pole Canyon Creek (see GW-15 on Figure 2-1). Selenium concentrations in alluvial groundwater decrease southward from the lower Pole Canyon area toward the north-central portion of Sage Valley, which indicates that attenuation is occurring. The wet meadow, organic-rich environment in Sage Valley is conducive to selenium attenuation.

Gain-loss surveys for Sage Creek identified several stream segments where discharge from the valley alluvial aquifer to Sage Creek was occurring. However, no increase in the Sage Creek selenium load could be attributed to discharging alluvial groundwater. The selenium load to alluvial groundwater has decreased significantly as a result of the 2006 NTCRA at the Pole Canyon ODA.

For alluvial groundwater, exceedances of groundwater MCLs for non-selenium COPCs were observed for aluminum and arsenic for some of the samples collected at several of the monitoring wells. However, these exceedances were not as consistent as those identified for selenium in alluvial groundwater and were typically co-located with elevated selenium concentrations.

2.2.3 Surface Water

Streams

The primary potential source areas within the Sage Creek basin are Panel A (southern portion), Panels D and E, and the Pole Canyon ODA. The primary potential source areas within the Tygee Creek basin are Panel A (northern portion), and Panels B and C. Concentrations did not exceed surface water quality criteria for any COPCs at the RI stream monitoring locations within the Tygee Creek basin; therefore, the following discussion focuses on surface water contamination in the Sage Creek basin.

The Pole Canyon ODA is distinct from the other Smoky Canyon Mine ODAs because of the cross-valley fill setting and the presence of an underlying shallow alluvial groundwater system associated with Pole Canyon Creek. Prior to implementation of the 2006 NTCRA, Pole Canyon Creek water entered the upstream side of the ODA and then was either lost to Wells Formation bedrock and alluvial deposits beneath the ODA or discharged at the downstream end, or toe, of the ODA. During the relatively dry months from late summer through early spring, most of the creek flow was lost under the ODA. Any creek water that did emerge from the ODA was quickly lost to alluvial deposits before the creek entered Sage Valley. During the fall of very dry years, all Pole Canyon Creek flow was lost underneath the ODA, with no flow discharging from the toe of the ODA. During typical spring runoff (i.e., high-flow) conditions, discharge from the toe of the ODA flowed into Sage Valley where it was still lost to alluvial deposits; occasionally, however, a portion of the creek flowed across Sage Valley and eventually flowed into North Fork Sage Creek and then to Sage Creek. Selenium concentrations in the water discharged at the toe of the ODA typically ranged from 0.5 to 1.5 mg/L, which exceeded the State of Idaho Surface Water Quality Criterion for Aquatic Life of 5 µg/L.

The 2006 NTCRA isolated the upper Pole Canyon Creek flows from the ODA and has significantly reduced the transport of selenium from the ODA to the environment. Since implementation of the NTCRA, water discharging from the toe of the ODA has increased selenium concentrations (typically ranging from 3 to 6 mg/L) because less water is available to dilute the infiltrated rainfall and snowmelt than previously. However, the magnitude and duration of flow has decreased substantially and toe seep water, if any, infiltrates to the subsurface close to the toe and generally does not reach lower Pole Canyon Creek downstream from the bypass pipeline discharge. As a result, most of the selenium mass load associated with toe seep flow is now transported to the underlying alluvial groundwater (and potentially the deeper Wells Formation aquifer) rather than directly to surface water that flows into Sage Valley. Selenium concentrations have dropped significantly in lower Pole Canyon Creek (less than 0.001 mg/L at stream sampling location LP-PD) as a result of the NTCRA. An exception to the decreased selenium load occurred during high-flow conditions in 2011 when the bypass pipeline flowed at less than design capacity and the creek flow and water quality briefly reverted to pre-NTCRA conditions. Under the 2013 NTCRA, a Dinwoody/Chert cover was installed on the Pole Canyon

ODA for further load reduction by decreasing net percolation resulting from infiltration of incident precipitation and snowmelt.

Surface discharge of Wells Formation water at Hoopes Spring and South Fork Sage Creek springs, with flow continuing downstream in lower Sage Creek, is the primary transport pathway for selenium leaving the Site. Water discharging from the springs provides the majority of the flow in lower Sage Creek under all flow conditions and contains selenium at concentrations up to 20 times higher than the State of Idaho Surface Water Quality Criterion for Aquatic Life of 5 µg/L.

The selenium load from these springs has been increasing over the past several years as selenium transported from the southern portion of Panel A, the Pole Canyon ODA, Panel D, and Panel E arrives, with recent loads of 3 to 4 pounds/day at Hoopes Spring and 0.7 to 0.8 pounds/day at South Fork Sage Creek springs. Selenium concentrations over the past several years at individual spring discharge locations have been as high as 0.134 mg/L at Hoopes Spring location HS and 0.0909 mg/L at South Fork Sage Creek springs location LSS-SP-N, although these concentrations have remained relatively constant over this period. Immediately downstream from the springs complex, the highest selenium concentrations in creek water have been 0.101 mg/L (HS-3, downstream of Hoopes Spring) and 0.0243 mg/L (LSS, downstream of South Fork Sage Creek springs).

The selenium load from these springs does not show significant seasonal trends and, therefore, in a given year the relatively constant load results in higher selenium concentrations in immediately downgradient streams (i.e., lower Sage Creek and Crow Creek) during low-flow conditions (late summer, early fall) and lower concentrations in high-flow conditions (spring runoff). As unaffected water enters the stream system from groundwater discharge and surface water from other creeks (e.g., Crow Creek upstream of the confluence with Sage Creek), selenium concentrations decrease and the selenium load remains relatively constant downstream of the inflow from the springs complex. However, selenium concentrations are still above the State of Idaho Surface Water Quality Criterion for Aquatic Life of 5 µg/L at the Wyoming border during low-flow conditions.

For surface water in streams, exceedances of surface water benchmarks for non-selenium COPCs was observed only for aluminum at several of the surface water monitoring locations. However, these exceedances were generally also associated with exceedances of the State of Idaho Surface Water Quality Criterion for Aquatic Life of 5 µg/L selenium. For springs at the Site (Hoopes Spring and South Fork Sage Creek springs), selenium was the only COPC which exceeded benchmarks or criteria.

<u>Seeps and Detention Basins</u>

Surface water sampling at the Site included surface expressions of seepage from the ODAs and detention basins that collect seepage and runoff from the pits and external ODA. Flow rates at some seeps can vary substantially seasonally, and at some locations surface seeps are only present in the spring. Evaluation of data collected before and/or during the RI showed elevated selenium concentrations in surface water features at five overburden seep areas (AS-2, DS-7, DS-10, ES-4, and ES-5; note that only DS-7 now flows with any regularity) and the associated detention basin waters downgradient from those seeps (AP-2, DP-7, DP-10, EP-4, and EP-5). Of the seeps currently flowing, DS-7 and LP-1 have the highest selenium concentrations. Detention basins receiving seep water with elevated selenium concentrations from the overburden areas also exhibit the highest selenium concentrations. Where selenium concentrations are elevated, other COPCs including arsenic are also elevated. Although elevated, the basin-water selenium concentrations are lower than in the nearby seep waters.

In addition to arsenic, exceedances of benchmarks for other non-selenium COPCs was observed for cadmium, chromium, nickel, vanadium, and zinc. However, these exceedances were not as consistent as those identified for selenium in seeps and detention basins and were typically co-located with elevated selenium concentrations.

The transport of solids by erosion and sediment transport is limited by the coarse texture of the overburden and the best management practices (BMPs) (e.g., soil cover, revegetation, etc.) that have been implemented during mining operations to control runoff and erosion from the ODAs. To the extent that COPC transport takes place by erosion of the source materials via surface water runoff from ODAs, those surface pathways end at the detention basins and do not extend to native soils or sediments or to Site streams. With the exception of a few isolated events where local failures of overburden fill resulted in overtopping of detention basins, overburden erosion and transport to native soils or sediments in stream drainages has not occurred.

2.2.4 Stream Sediment

Potential sediment transport pathways from source areas to local surface water drainages were evaluated in the RI by comparing selenium concentrations from upstream to downstream monitoring locations in streams. For stream sediments, selenium exceeded the screening-level benchmark for sediment (2 milligrams per kilogram [mg/kg]) at the following locations, which are all downstream from mine-disturbance areas: lower Pole Canyon Creek (LP-PD), the stream downstream from Hoopes Spring (HS-3), North Fork Sage Creek in northern Sage Valley (NSV-6), and lower Sage Creek (LSV-2C, LSV-3, and LSV-4).

Elevated concentrations of selenium in stream sediments in the locations noted above are a result of selenium transport in surface water (from groundwater discharging at Hoopes Spring and South Fork Sage Creek springs) and sorption of the dissolved selenium to stream sediments. The presence of elevated selenium and other COPC concentrations in lower Pole Canyon Creek sediment samples is also due to the deposition of overburden slope materials into the creek during a past slope failure at the toe of the ODA in spring 1996. The slope has since been stabilized, but residual sediments remain in the creek bed below the ODA. With the exception of Pole Canyon Creek immediately downstream of the Pole Canyon ODA, there are no surface transport pathways for sediment from source areas to streams. Sediment that is eroded in stormwater runoff from the ODAs is collected in detention basins and therefore prevented from entering streams.

2.2.5 Terrestrial and Aquatic Biota

Terrestrial and aquatic biota data were collected during the RI for characterization of selenium in fish tissues, benthic invertebrate tissues, aquatic vegetation, small mammals, and terrestrial invertebrates.

Terrestrial invertebrate and small mammal tissue selenium concentrations from ODAs with minimal or no cover material and from overburden seep areas are generally elevated in comparison to samples from adjacent area soils. The elevated concentrations are related to the abiotic selenium levels and may indicate bioaccumulation of selenium in the food chain. At the Site, this is particularly apparent in Panel A, Panel D, and the Pole Canyon ODA where selenium concentrations in both terrestrial invertebrates and small mammals were elevated relative to the areas of the Site where selenium concentrations in soil are lower (i.e., Panel E, northern Sage Valley, and the samples collected from areas adjacent to mine disturbances). Other chemicals with elevated concentrations that may pose potentially unacceptable risks to terrestrial biota included cadmium, chromium, copper, lead, manganese, molybdenum, vanadium, and zinc. However, the risks from these COPCs were generally lower than from selenium and were generally co-located with areas of selenium risk, primarily in mined areas with either no cover (i.e., direct revegetation of overburden) or relatively thin topsoil-only reclamation.

Copper concentrations in small mammal tissue samples collected during the RI ranged from 11.9 to 3,900 mg/kg with a mean concentration equal to 387 ± 584 mg/kg (mean ± standard deviation). These concentrations were much higher than anticipated and the samples containing the higher copper concentrations showed no spatial pattern or relationship with any mine panel or reclamation type. Also, the results were up to two orders of magnitude higher than results from previous monitoring at Smoky Canyon Mine and at other phosphate mines in southeast Idaho. For comparison, copper concentrations in small mammals collected from the Site in 2004 (49 samples) as part of the SI (NewFields 2005a) and summarized in the RI Report (Formation 2014c) were much lower and less variable, ranging from 10.5 to 17 mg/kg with a mean concentration equal to 14 ± 1.6 mg/kg.

Because of the uncertainties associated with the RI small mammal copper results from sampling in 2010, additional sampling of small mammal tissues was performed in July 2016. Sampling was conducted at 11 locations in the areas where unexpectedly high copper concentrations were observed in the original (July 2010) RI samples (Formation 2016e – SAP Addendum 08). Results from the additional 2016 sampling show lower copper concentrations, ranging from 10.7 to 936 mg/kg with a mean concentration equal to 60.3 ± 142 mg/kg. These concentrations are still anomalously elevated and highly variable relative to previous monitoring at the Site, and are much higher than measured at other phosphate mines in southeast Idaho and in relation to published copper concentrations for small mammal tissue samples. Specifically, the concentrations are anomalously elevated when compared to copper mines and/or smelters where elevated copper concentrations are present in soils and exposure has been documented (for example, NewFields 2005b). An upcoming memorandum will present information to confirm that the magnitudes of the RI small mammal tissue results are anomalous. It will include the results of the previous and recent small mammal tissue sampling and analysis at Smoky Canyon Mine, results of small mammal sampling at other phosphate mines in southeast Idaho, a literature summary of other small mammal data, and an evaluation of laboratory procedures and split sample laboratory analysis.

Elevated selenium concentrations in fish tissue immediately downstream from Hoopes Spring and in lower Sage Creek appear to be directly correlated with surface water concentrations in these stream reaches. Dietary sources may also contribute, as selenium concentrations in benthic macroinvertebrates at these locations were slightly elevated with respect to background. Selenium concentrations in macrophytes and periphyton also followed a similar pattern, with the highest selenium concentrations in lower Pole Canyon Creek.

2.3 Fate and Transport Summary

As identified in the RI, pathways for transport of selenium identified at the Site are:

- Release from backfilled pits and external ODAs and transport downward to the underlying Wells Formation groundwater at the Site. Transport in the groundwater and discharge to surface water via springs and, when pumping, discharge at the Industrial Well (GW-IW) in the northern portion of the Site.
- Release from the Pole Canyon ODA to alluvial groundwater beneath the Pole Canyon Creek channel. This alluvial groundwater continues into northern Sage Valley and likely discharges to downgradient surface water but the associated selenium load addition is too small to detect.
- Surface water flow through the base of the Pole Canyon ODA and into Pole Canyon Creek prior to implementation of the 2006 NTCRA and during an isolated event in 2011 when the bypass pipeline was operated at less than design capacity. Surface water runoff from other ODAs (i.e., stormwater runoff and seeps from ODA toes) is contained in ponds and does not reach Site streams via the surface pathway.

- Sediment transport from ODAs primarily during active mining and immediately afterwards (before reclamation). Sediment is contained in stormwater detention basins and does not reach Site streams. The exception is Pole Canyon ODA where sediment was transported to the Pole Canyon Creek channel, primarily by a slope failure in spring 1996.
- Direct uptake by plants growing on overburden.

During scoping of the RI, as summarized in the RI/FS Work Plan (Formation 2011a), the wind dispersion and air deposition potential pathway was identified as insignificant at the Site based on findings of the SI (NewFields 2005a). Therefore, this potential pathway was not addressed in the FS.

2.4 Conceptual Model

CSM diagrams for human, ecological, and livestock receptors are presented in the Site-specific risk assessment reports (Figure 4-1 in SSHRA [Formation 2015a], Figure 2-11 in SSERA [Formation 2015b], and Figure 3-1 in SSLRA [Formation 2016a], respectively). Information on contaminant sources, migration routes, exposure pathways, and receptors were used to develop an understanding of the Site and to evaluate potential risks.

2.4.1 Contaminant Sources

Overburden disposed in backfilled mine pits and external ODAs is the source of selenium and other COPCs to the environment. Overburden is removed during active mining to access the underlying phosphate ore. The primary sources of selenium within the overburden are the sulfides and organic matter present in the mudstone and center waste shale from the Meade Peak Member of the Phosphoria Formation. The source areas of the Site include the backfilled mine pits and external ODAs of Panels A through E.

The release of selenium from overburden materials occurs by (1) interaction with infiltrating water/leaching and (2) weathering of overburden. Dissolution of soluble solids and release of associated selenium to infiltrating water represents a relatively short-term release mechanism that takes place primarily during overburden handling and initial disposal. Weathering operates by oxidation of minerals or organic matter to release selenium. Oxidation processes may begin as soon as overburden is excavated, and continue in the final disposal setting.

2.4.2 Migration Routes

Pathways for migration of selenium from source areas to groundwater and surface water are described below.

Groundwater

Groundwater pathways for transport of selenium include (1) transport by alluvial groundwater and (2) transport by Wells Formation groundwater.

A valley-fill alluvial groundwater system exists in Sage Valley. The water table in this system is typically less than 30 feet below the ground surface and, at some locations, is intercepted seasonally by Sage Creek. The valley system is connected with shallow alluvial deposits at the mouths of the tributary drainages, and specifically is affected by transport from the alluvial system underlying and immediately downgradient of the Pole Canyon ODA. The Sage Valley alluvial groundwater flow system is isolated from the Wells Formation by the West Sage Valley Branch Fault that parallels the western side of Sage Valley. In essence, the valley alluvial system has the configuration of a large basin, with flow contributions coming primarily from tributaries along the west side of the valley.

Groundwater flow in the upper Wells Formation aquifer is controlled by the combined effects of the West Sage Valley Branch Fault, which is a barrier to flow to the east, and the discharge zone created by the springs complex to which local and regional Wells Formation groundwater ultimately flows. Together, these springs discharge Wells Formation groundwater in excess of 10 cubic feet per second (cfs) to the Sage Creek drainage; the spring discharge comprises the majority of flow in the lower Sage Creek drainage under all flow conditions. In the north end of the Site, groundwater flow paths within the Wells Formation are also influenced by pumping at the Industrial Well (GW-IW), which generates a large area of hydraulic influence when operated at typically high pumping rates.

As part of the RI, analytical and numerical models were developed to characterize the transport of selenium in groundwater in the Wells Formation aquifer in the southern and northern portions of the Site. An analytical model was developed for the southern groundwater flow system (south-end model), to evaluate the relative contribution from source areas to the selenium mass load discharged at the springs complex. An analytical model and numerical models were also developed for the northern groundwater flow system (north-end models) to estimate potential groundwater concentrations at the northern lease boundary. The models provide a line of evidence in evaluation of the dynamic nature of varying historical Site conditions that have influenced selenium transport over time. Specific objectives of the models included:

- Identify the relative selenium contribution to the springs complex from each mine panel on a year-by-year basis and estimate the future contributions based on past, current, and future reclamation activities/removal actions;
- Estimate potential selenium impacts at the northern lease boundary based on past, current, and future reclamation activities/removal actions; and
- Account for Site conditions that change with time due to disturbance and reclamation activities.

The results of the modeling are reported in Appendix H of the RI Report (Formation 2014c). The key findings with respect to the identification of remedial alternatives are summarized here. As noted above, in the south end of the Site Wells Formation groundwater from the Site area discharges at the springs complex. The models developed for the RI account for selenium loading to Wells Formation groundwater resulting from leaching from the seleniferous overburden by infiltrating precipitation and by storm water run-off where detention basins occur over seleniferous backfill material. This loading is shown as the black dotted line on Figure 2-5.

In general, the maximum selenium loading to groundwater occurs during active mining and prior to completion of reclamation. Once an area is reclaimed, selenium loading to the groundwater reduces over time due to the reduction of releases from the overburden (i.e., the source term characteristics). For example, mining at Panel D began in 1993 and continued through 1998. Reclamation at Panel D began in 1996 and was completed in 2002. Mining at Panel E occurred in 1998 through 2006. Portions of Panel E remained open through 2011 to receive backfill from Panel F. The majority of reclamation was competed in 2013. Each of these mine panels have the same characteristics of peak loading during active mining and reduced loading after reclamation. The relative magnitude of loading after reclamation is affected by the reclamation type; infiltration-reduction covers result in lower levels of loading.

The Pole Canyon ODA is a unique setting because it is a cross-valley fill with Pole Canyon Creek flowing through the ODA. It received seleniferous backfill from 1985 through 1990. Prior to backfilling, a coarse-grained chert material was placed at the base of the ODA to create of a zone of higher hydraulic conductivity through which Pole Canyon Creek flowed. Selenium was mobilized from the overburden by the creek water as it passed through the ODA (1985 through 2007). The first NTCRA at the Pole Canyon ODA included a pipeline to divert a portion of the Pole Canyon Creek stream flow around the ODA, an infiltration basin that directs the remaining clean Pole Canyon Creek flow to the Wells Formation aquifer upstream of the ODA, and a channel that controls run-on to the Pole Canyon ODA. These actions were completed in 2008 and significantly reduced the mobilization of selenium and subsequent loading to groundwater (see Figure 2-5). The 2015 NTCRA included storm water controls and a Dinwoody cover system, further reducing selenium loading to groundwater.

The estimated loads from each panel to groundwater are transported to the springs complex based on the travel time as shown by the blue lines on Figure 2-5. The loading from panels that are farther away (i.e., Panel A) take longer to reach the springs than the loads that are closer (i.e., Panel E) The loads are then added to estimate the total selenium load at the springs complex over time, as shown on Figure 2-6. Overall, the modeling effort found that selenium released during active mining began to arrive at the springs complex in the late 1990s and is predicted to peak in the 2015/2016 time frame. Because mining began farther north and has progressed south, these arrival signatures have overlapped (Figure 2-6). In each case, the loading curves from a given panel peak due to the effects of active mining and then reduce to a steady-state loading reflecting the post-mining/reclaimed condition. For the Pole Canyon ODA, diversion of Pole Canyon Creek around the ODA starting in 2007 and completion of the NTCRA cover in 2015 are predicted to begin reducing loading at the springs complex in the late 2020s.

The predicted loading from key areas to the springs complex in 2050 (i.e., after the effect of all completed actions is realized) is due to infiltration into the ODAs and subsequent release and transport of selenium shown in Table 2-2. These values show the relative importance of each source area to selenium loading in the long term and can be used to identify where remedial actions might be needed to meet RAOs. As shown, the majority of loads are predicted to come from the Panel A area and Panel D area. The Panel A and D areas have relatively less protective covers than the more recent covers installed on portions of Panel E and the Pole Canyon ODA and therefore these will be the focus of the evaluation of remedial alternatives in this FS.

North-end modeling analyses were conducted to evaluate two issues regarding the influence of mining activity on selenium concentrations in the Wells Formation groundwater:

- Extent of containment provided by pumping at the Industrial Well (GW-IW); and
- Potential north-end source area influence on groundwater not captured by GW-IW.

An analytical model and a numerical model were developed to address these issues. Both north-end models used results of the GIS-based source term model to account for the spatial and temporal distribution for multiple source areas and associated selenium loading to the Wells Formation aquifer.

Assessment of containment provided by pumping at GW-IW resulted in a structural influence (e.g. faulting) capture zone assumption. Figure 2-7 illustrates the capture zone and seleniferous backfill areas inside the capture zone. The applicability of the structural control assumption suggests that sources in Panels A and C are captured by GW-IW. The GW-IW analysis, however, does not provide clear evidence of capture of Panel B sources.

To evaluate the potential groundwater impacts resulting from Panel B sources, assuming Panel B sources are not captured by GW-IW, a numerical groundwater transport model was developed to simulate a northerly migration of selenium in the Wells Formation toward the lease boundary. The numerical model used MODFLOW and MT3DMS to simulate groundwater flow and solute transport, respectively. Seleniferous source areas outside the GW-IW capture zone are shown in Figure 2-8. Figure 2-9 illustrates the estimated selenium concentration at the northern lease boundary assuming a northerly flow path.

Surface Water

Surface water pathways for transport of selenium include (1) transport by runoff from ODAs, (2) transport by seep flow from ODAs, and (3) transport by stream flow.

Based on the RI (Formation 2014c), there is no evidence that stormwater runoff transports selenium to surface waters in the drainages that cross mining-disturbed areas. However, runoff from ODAs to detention basins and subsequent infiltration to Wells Formation groundwater is a potential transport pathway.

The seeps represent a transport pathway for selenium from the ODAs to soil below ODA seeps and, for DS-7 and ES-3, to detention basins below these ODA seeps. At the seeps where flow was present during RI data collection (LP-1, DS-7, and ES-3 [for only a portion of the time]), ongoing infiltration of seep water into the subsurface also represents a potential transport pathway to groundwater. The highest potential selenium loading to groundwater is associated with seeps LP-1 and DS-7 which have the highest selenium concentrations and mass loading rates. These two seeps have the potential to infiltrate into the underlying deep Wells Formation aquifer. Seep LP-1 also has the potential to infiltrate into the shallow alluvial groundwater flow system that overlies the Wells Formation.

The RI (Formation 2014c) indicated that Smoky Creek, Pole Canyon Creek, Sage Creek, and South Fork Sage Creek have not received runoff from mine-disturbance areas. However, the Wells Formation aquifer discharges groundwater to surface water at Hoopes Spring and South Fork Sage Creek springs; the selenium mass load discharging at the springs complex originates entirely from Wells Formation groundwater. The flow from Hoopes Spring continues downstream into Sage Creek upstream of its confluence with South Fork Sage Creek, and the flow from South Fork Sage Creek springs enters South Fork Sage Creek near the groundwater discharge locations.

2.4.3 Exposure Pathways

The risk assessments evaluated numerous exposure pathways and receptors.

Potentially complete significant human exposure pathways are:

- Ingestion of surface water and groundwater for domestic drinking water supply; and
- Ingestion of Site-derived livestock (beef).

Potentially complete significant exposure pathways for terrestrial ecological receptors are:

- Incidental ingestion of overburden material and soil;
- Ingestion of small mammals; and
- Ingestion of terrestrial plants growing on overburden material and soil.

Potentially complete significant exposure pathways for riparian and aquatic receptors are:

- Ingestion of surface water and incidental ingestion of soil (riparian only) and sediment (fish and riparian receptors); and
- Ingestion (food web uptake).

Potentially complete significant exposure pathways for livestock are:

- Ingestion of terrestrial plants as forage; and
- Ingestion of surface water as drinking water. Ingestion of groundwater would represent an exposure risk only if wells are developed for stock watering.

2.4.4 Potential Receptors

The risk assessments identified the following potential receptors that had the potential to be exposed to selenium and other COPCs at levels that could present an unacceptable risk:

<u>Human</u>: Current and potential future seasonal ranchers and Native Americans, and potential future recreational campers and hypothetical residents (assumed only on private lands).

<u>Ecological</u>: Terrestrial vegetation and terrestrial and riparian wildlife such as mice, vole (riparian only), rabbits, mink (riparian only), raccoons (riparian only), ducks (riparian), birds, coyotes, and mule deer. Aquatic receptors are fish, amphibians, and benthic invertebrates in lower Sage Creek.

<u>Livestock</u>: Sheep. Cattle and horses may also potentially be exposed.

2.5 Risk Assessments

The primary objectives of the SSHHRA and SSERA were to evaluate the possible human health and ecological risks associated with potential exposure to environmental media at the Site to help determine the need for remedial action. The primary objective of the SSLRA was to evaluate potential livestock risks associated with potential exposure to environmental media to provide the regulatory agencies with the information necessary to make informed decisions regarding range management.

2.5.1 Human Receptors

Arsenic was the only chemical for which cancer risk estimates exceeded the target cancer risk goal of 1E-05, and arsenic was identified as a human health chemical of concern (HH COC) for the seasonal rancher, recreational camper, Native American, and hypothetical resident receptor scenarios, with contributions from several environmental media.

Seasonal Rancher

Potentially unacceptable current and future risks are from:

- Beef - arsenic

Ingestion of beef was the primary contributor of cancer risk for the seasonal rancher and arsenic was the only chemical for which cancer risk estimates exceeded the target cancer risk goal of 1E-05. The exposure point concentration (EPC) for beef was modeled based on Sitewide arsenic concentrations in samples of soil, forage plants, and/or water. Concentrations of arsenic in vegetation are elevated in areas of the Site that have overburden at the surface, and livestock may be exposed if they graze in those areas.

Thallium exposures exceeded the USEPA non-cancer threshold for ingestion of beef by the seasonal rancher, with elevated thallium concentrations in overburden within the mine area influencing the calculated uptake. However, data from regional studies suggest that thallium concentrations in soils at the Site are within the range of natural background concentrations. Therefore, risks from thallium would be considered only within the context of natural background exposure along with the considerable uncertainty in the uptake coefficient used to model beef concentrations.

Recreational Camper and Native American

Potentially unacceptable future (Recreational Camper) and current and future (Native American) risks are from:

- Surface water (domestic drinking water supply) - arsenic

Surface water locations associated with seeps (DS-7 and LP-1) and detention basins (DP-7 and EP-2) contain arsenic concentrations that exceed the Idaho drinking water standard (0.01 mg/L). These locations contributed to exposure and lifetime cancer risks in excess of 1E-05. Arsenic concentrations at all other surface water and groundwater sampling locations are lower than the drinking water standard.

Hypothetical Resident

Potentially unacceptable future risks are from:

- Groundwater (domestic drinking water supply) – selenium and arsenic

Although land use and population statistics indicate that the Site is unlikely to convert to residential use, the hypothetical resident receptor was assessed for private lands in accordance with Forest Service guidance (USFS 2013b). Potentially unacceptable risks (cancer risks in excess of 1E-05) from selenium and arsenic were estimated for the hypothetical resident scenario in which groundwater is used for domestic drinking water supply. Selenium concentrations in groundwater exceeded the Idaho state drinking water standard (0.05 mg/L) at several wells immediately downgradient of the Pole Canyon ODA, but concentrations in groundwater from all other locations were lower than the drinking water standard. These wells also contained arsenic concentrations that exceeded the Idaho drinking water standard (0.01 mg/L). Both locations are immediately downgradient of the Pole Canyon ODA and are known to be affected by past infiltration of water into the ODA, and downgradient transport in alluvial and Wells Formation groundwater.

2.5.2 Ecological Receptors

Selenium is the primary risk driver for both current and future aquatic and terrestrial biota. Conclusions for aquatic receptors are presented by media type to reflect the risk analysis organization and regulatory framework for aquatic environments. Terrestrial risk analysis is based on ingestion of COPCs from multiple exposure media within each habitat.

Aquatic

Potentially unacceptable current and future risks for aquatic receptors are from:

- Surface water – selenium
- Fish tissue – selenium

Selenium is the primary risk driver in surface waters across several drainages. Other COPCs that exceeded Toxicity Reference Values (TRVs) primarily in surface waters included aluminum, arsenic, cadmium, iron, nickel, and zinc. Where elevated, these COPCs do not likely represent unacceptable risk because of the very limited potential for exposure (e.g., seeps or ephemeral habitats) of receptors to these environments. Locations where elevated selenium concentrations exist and pose risk to aquatic receptors correspond to areas of known inputs such as Hoopes Spring and South Fork Sage Creek and their downstream receiving waters, and Pole Canyon Creek.

Selenium concentrations in surface water from Pole Canyon Creek, North Fork Sage Creek, Hoopes Spring, South Fork Sage Creek, Lower Sage Creek, and Crow Creek exceeded the State of Idaho Surface Water Quality Criterion for Aquatic Life (5 µg/L). However, the current state of the science indicates that selenium concentrations in egg/ovary tissues from fish and other aquatic organisms provide the best measure of effects for aquatic life. To date, egg/ovary data have largely been compiled for fish species which have thus far been demonstrated to be suitably sensitive. Therefore, fish tissue data should be used to assess risk to aquatic receptors rather than surface water data.

Selenium in fish tissue is the best measure of exposure and potential risk for fish and other aquatic receptors. Whole body selenium fish tissue concentrations downstream of major sources exceeded the USEPA-derived National Criterion (8.5 mg/kg dry weight [dw]), the brown trout threshold derived by USEPA (13.2 mg/kg dw) and the Simplot-derived threshold for brown trout (14.14 mg/kg dw) at Hoopes Spring, lower Sage Creek, and lower Crow Creek. Overall, fish tissue from Crow Creek and South Fork Sage Creek do not exceed these thresholds. The physical habitat at Pole Canyon Creek (LP-PD) and North Fork Sage Creek (NSV-6) does not support any fish, and benthic tissue data indicated that selenium bioaccumulation in those tissues was acceptable. Pole Canyon Creek at the LP-1 seep poses unacceptable risks to higher trophic level organisms that may obtain food or water from that location. Other COPCs that were elevated in fish tissues included aluminum and essential micronutrients copper, iron, and zinc. The contributions of background to tissue concentrations, as well as the reliability of the TRVs used to assess potential risks, were discussed in the Uncertainty Analysis of the SSERA (Formation 2015b).

Selenium in sediments from Hoopes Spring (HS-3) and North Fork Sage Creek (at NSV-6), and at Pole Canyon Creek (LP-PD, LPT-1, LPT-2, and LPT-3) exceeded the sediment TRV. However, the TRVs for selenium in sediments are not based on toxicity to benthic invertebrates. Literature-derived tissue TRVs for benthic invertebrates, compared to concentrations measured for invertebrate tissues collected from across the Site, indicate selenium in invertebrate tissues potentially poses a risk only in lower Sage Creek. Although sediment in upper Sage Creek (upstream of inflow from Hoopes Spring) was identified as posing a risk, it was clearly a function of a single location (SV-1, an irrigation ditch) where consistently higher selenium concentrations were found. However, as mentioned above, the pathway for exposure is incomplete, as connectivity to downstream waterbodies is limited and inconsistent. In addition to selenium in sediments, other COPCs that were elevated above TRVs included barium, cadmium, chromium, nickel, manganese, silver, and zinc.

The concentration of selenium in biotic and abiotic media exceeds TRVs for aquatic receptors at certain locations (Formation 2015b). COPCs at the LP-1 seep and at SV-1 pose unacceptable risks, however, whether these concentrations represent significant ecological risk is often a function of habitat and connectivity of surface water to source areas or accessibility by terrestrial organisms. As discussed in the SSERA, the LP-1 seep at the toe of the Pole Canyon ODA is isolated and typically disconnected from the main stream due to installation of the Pole Canyon Creek bypass pipeline (under the 2006 NTCRA). Therefore, the potential for exposure to these concentrations is extremely limited for aquatic ecological receptors. For SV-1, which is located in an irrigation ditch near Sage Creek, downgradient of detention basin DP-2, flow is ephemeral at best and no appreciable aquatic habitat is present. Because permanent aquatic habitat is limited or absent, no adverse effects on aquatic populations is likely due to the lack of exposure.

Terrestrial Upland

Potentially unacceptable current and future risks to terrestrial upland receptors are from:

- Food/Soil/Surface Water (Panel A Area 2, Panel D North and South) – selenium

Selenium in soils, vegetation, and terrestrial invertebrates and small mammals is the primary risk driver at the Site. Other chemicals identified as posing potentially unacceptable risks in the Tier 1/Tier 2 analysis included cadmium, copper, lead, vanadium, and zinc; however, the risks from these ecological chemicals of concern (ECOCs) were lower than from selenium and were generally co-located with areas of selenium risk.

Elevated concentrations of ECOCs were observed primarily in mined areas with either no cover (i.e., direct revegetation of overburden) or topsoil-only reclamation and elevated concentrations of ECOCs in soils corresponded with higher exposure and risks. Risks are highest in Panel A Area 2, Panel D North and South, and on the Pole Canyon ODA (prior to construction of the cover system in 2015 under the 2013 NTCRA) which represent areas where exposure to selenium-bearing overburden materials is expected to be highest. Exposure and risks were considerably lower for northern Sage Valley, Panel A Area 1, and Panel E (Figure 2-10). Risks were lowest in the areas with a Dinwoody/Chert cover and highest in the areas with no cover.

Based on the SSERA conclusions, risks to sub-populations of small mammal and bird receptors inhabiting Panel A Area 2, and Panel D North and South could not be ruled out using the available data. Exposure to the terrestrial receptors and potential risk is elevated compared to the surrounding areas, but it is unknown whether any actual effects are occurring to the populations inhabiting those areas. No data are currently available to address the presence or absence of population-level effects from selenium as predicted in the SSERA (Formation 2015b). While no detailed population studies were conducted in those areas, small mammal sampling was successful in both 2010 and 2016 suggesting the presence of a functioning small mammal community. The presence of a functioning community does not preclude the SSERA conclusions, but it does represent an uncertainty regarding the predictive ability of the risk-models used in predicting population-level effects to the small mammal receptor.

Riparian

Potentially unacceptable current and future risks to riparian receptors are from:

- Food/Soil/Sediment/Surface Water (seeps and springs) – selenium

Similar to the upland areas of the Site, selenium is the primary risk driver; however, other ECOCs were identified for riparian receptors including cadmium, chromium, copper, lead, manganese, molybdenum, vanadium, and zinc. As indicated for the upland areas, exposure and risk associated with the non-selenium ECOCs is lower than risks predicted from selenium. Elevated selenium concentrations in semi-aquatic habitats at the Site were limited to a few sampling locations. Selenium exposures were much higher than elsewhere at seeps DS-7 (east of Panel D) and ES-4 (east of Panel E), as well as riparian location LP-PD (Pole Canyon). Risk was lowest at seep ES-3 (east of Panel E).

2.5.3 Livestock Receptors

Potentially unacceptable current and future risks to livestock are from:

- Vegetation - selenium
- Surface water - selenium

Selenium is the primary risk driver for livestock. While exposure to several other COPCs (barium, iron, manganese, and molybdenum) exceeded risk benchmarks in some areas, the elevated concentrations coincided with selenium exposures in most cases. Exposure to these other COPCs was described as likely representing background conditions. Potentially unacceptable risks to livestock from selenium were calculated for vegetation, surface water, and groundwater (if used for stock watering in the future).

The greatest potential for adverse effects from vegetation is from sampling locations in mine-disturbance areas in the Pole Draney and Sage Valley grazing allotments (Figure 2-11) where selenium concentrations exceeded the acute TRV. Of the five grazing allotments that overlap the Site, only the Sage Valley Allotment contained average concentrations that exceeded the chronic TRV. Site-specific risks from selenium in surface water are restricted to seep and spring locations immediately downgradient of the Pole Canyon ODA and Panel D; however, these seep areas are typically fenced to prevent access. Overall chronic and acute risks from selenium are unacceptable primarily due to surface water and vegetation associated with backfilled pits and ODAs in the Sage Valley and Pole Draney grazing allotments. Exposure in other allotments was within acceptable levels.

3.0 REMEDIAL ACTION OBJECTIVES

This section provides Site-specific objectives and goals for remedial actions at the Site. Preliminary RAOs were identified in the RI/FS Work Plan (Formation 2011a), based on the findings from the SI (NewFields 2005a). These Preliminary RAOs have been updated in this section to incorporate the findings of the RI and risk assessments and the evaluation of ARARs.

Section 300.430(e) of the 1990 National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requires that the remedial alternative development process be initiated by developing RAOs, identifying GRAs that address the RAOs, and performing an initial screening of applicable remedial technologies. The overarching goal of the remedy evaluation process is to provide the basis for selection of a remedy that is protective of human health and the environment, and meets ARARs.

3.1 Environmental Conditions of Concern

Based on the key findings of the RI and risk assessments (see Section 2), the following environmental conditions of concern have been identified to be addressed by the Site remedy:

- Releases of selenium from overburden (both during mining and after mining) stored in backfilled pits and external ODAs with minimal or no covers that have resulted in MCL exceedances in groundwater in the Wells Formation aquifer including discharges at Hoopes Spring and South Fork Sage Creek springs and occasionally at the pumping Industrial Well (GW-IW) (Figure 3-1). The relative magnitude of selenium loading from the sources to the springs in 2050 (i.e., after reclamation and NTCRA actions are fully effective) shows that Panel A Area 2 and Panel D (including the external ODA) are the primary sources. These areas are the focus of the FS evaluation for additional source control. Arsenic is also present at concentrations above the MCL in groundwater at some wells due to releases from the ODAs, although these are typically the wells with elevated selenium concentrations.
- Releases of selenium from overburden in the Pole Canyon ODA that have resulted in MCL exceedances in groundwater in the alluvial groundwater system in lower Pole Canyon and northern Sage Valley (Figure 3-1). These releases have been reduced as a result of the Pole Canyon ODA NTCRA cover constructed in 2015.
- Migration and discharge of Wells Formation groundwater to surface water at Hoopes Spring and South Fork Sage Creek springs resulting in selenium concentrations above the State of Idaho Surface Water Quality Criterion for Aquatic Life at the springs (HS-3, LSS) and downstream in lower Sage Creek (LSV-2, LSV-3, LSV-4) and Crow Creek (CC-1A, CC-WY-01) (Figure 3-2). Other COCs that exceeded TRVs primarily in surface waters included aluminum, arsenic, cadmium, iron, nickel, and zinc. Where elevated, these COCs do not likely represent unacceptable risk because of the very limited potential for exposure (e.g., seeps or ephemeral habitats) of receptors to these environments.

- Risk to aquatic biota due to exceedances of whole body USEPA-derived and Simplot-derived fish tissue thresholds for selenium at Hoopes Spring (HS-3) and downstream from Hoopes Spring in lower Sage Creek (LSV-2, LSV-3, LSV-4) (Figure 3-3). Other COCs that were elevated in fish tissues included aluminum and essential micronutrients copper, iron, and zinc. However, risk related to these COCs may be overstated due to the contributions of background to tissue concentrations, as well as the reliability of the TRVs used to assess potential risks (Formation 2015b).
- Risk to terrestrial biota from soil and biotic media (vegetation, invertebrates, and small mammals) with elevated selenium concentrations in overburden on backfilled pits and external ODAs with minimal or no covers in the Panel A Area 2 (south of mill) and Panel D areas, and in overburden seep/riparian areas downgradient (east) of Panel D (DS-7), Panel E (ES-4), and the Pole Canyon ODA (LP-PD) (Figure 3-4). For terrestrial biota, risk from Pole Canyon ODA has been eliminated as a result of the Pole Canyon ODA NTCRA cover constructed in 2015. Other COCs were identified for terrestrial receptors including cadmium, chromium, copper, lead, manganese, molybdenum, vanadium, and zinc. However, exposure and risk associated with the non-selenium COCs are lower than predicted from selenium and were generally co-located with areas of selenium risk, primarily in mined areas with either no cover (i.e., direct revegetation of overburden) or relatively thin topsoil-only reclamation.
- Future risk to human receptors (Recreational Camper or Native American) and current risk to human receptors (Native American) from ingestion of surface water where arsenic concentrations exceeded the Idaho drinking water standard in surface water seeps downgradient (east) of Panel D (DS-7) and the Pole Canyon ODA (LP-1), and surface water in detention basins downgradient of Panel D seep DS-7 (DP-7) and Panel E (EP-2) (Figure 3-5).
- Future risk to human receptors (Hypothetical Resident) in which groundwater from wells on private lands is used for domestic drinking water supply, where arsenic concentrations in groundwater exceeded the MCL immediately downgradient of the Pole Canyon ODA (GW-15, GW-16) (Figure 3-5).
- Future and current risk to human receptors (Seasonal Rancher) from ingestion of beef as the primary contributor of cancer risk, based largely on arsenic concentrations (calculated on a Sitewide basis) for soil with the highest concentrations in Panel A Area 2, detention basin AP-3 (adjacent to west end of Pole Canyon ODA), Panel D seep DS-7 area, detention basin DP-7, and detention basin EP-4 (Figure 3-5). As noted in Section 2.5, thallium exposures to human receptors (Seasonal Rancher) from beef consumption were elevated (with considerable uncertainty in the uptake coefficient), although data from regional studies suggest that thallium concentrations in soils at the Site are within the range of natural background concentrations.
- Future risk to human receptors (Hypothetical Resident) in which groundwater from wells on private lands is used for domestic drinking water supply, where selenium concentrations in groundwater exceeded the MCL immediately downgradient of the Pole Canyon ODA (GW-15, GW-16) and downgradient of Pole Canyon in northern Sage Valley (GW-22, MP01, MP02, and MP03) (Figure 3-6).
- Future acute risk to livestock due to exposure to selenium in vegetation associated with the mine-disturbance area (Panel A Area 2, Panel D North, and immediately downgradient from the Pole Canyon ODA toe seep LP-1 and Panel E seep ES-4) within

the Sage Valley and Pole Draney grazing allotments (Figure 3-7). Acute selenium risks from surface water are restricted to areas immediately downgradient of the Pole Canyon ODA (seep LP-1) and Panel D (seep DS-7 and downgradient detention basin DP-7) (Figure 3-7). If groundwater is used for stock watering, then acute selenium risks would result from use of Wells Formation groundwater immediately downgradient from the Pole Canyon ODA (GW-16) and immediately downgradient and southeast of Panel E (GW-25), or from use of alluvial groundwater immediately downgradient from the Pole Canyon ODA (GW-26, GW-15) (Figure 3-7).

3.2 Applicable or Relevant and Appropriate Requirements

Identification and evaluation of ARARs are integral components of the FS process to determine whether remedial alternatives can protect human health and the environment. The development of remedial alternatives under CERCLA relies, in part, on the identification of the ARARs which any action must meet, unless specific ARARs qualify for a waiver and are waived.

Applicable, Relevant and Appropriate, and To-Be-Considered Standards

For onsite activities, CERCLA requires compliance with both applicable requirements (i.e., those that would apply to a given circumstance at any site or facility) and those that the Forest Service deems to be relevant and appropriate (even though they do not apply directly), based on the unique conditions at a site. Applicable requirements are cleanup standards; standards of control; and other substantive requirements, criteria, or limitations promulgated under federal or state laws that specifically address a hazardous substance, constituent, removal action, location, or other circumstance found at a site. Relevant and appropriate requirements, while not applicable to a hazardous substance, pollutant, contaminant, removal action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the site such that their use is well-suited (40 Code of Federal Regulations [CFR] 300.5).

ARARs are potential or preliminary until finalized in the ROD. The NCP provides for the waiver of ARARs under certain circumstances (40 CFR 300.415[f][1][i][C]). Because this is a preliminary evaluation of potential ARARs, with remedial alternatives still being developed, any identification of the need for ARAR waivers is preliminary.

In addition to ARARs, the NCP states that where ARARs do not exist, agency advisories, criteria, or guidance are to be considered useful “in helping to determine what is protective at a site or how to carry out certain actions or requirements” (55 Federal Register 8745). These sources of information are referred to as “To-Be-Considered” (TBC) standards.

The NCP preamble states, however, that provisions in the TBC category “should not be required as cleanup standards, because they are, by definition, generally neither promulgated nor enforceable, so they do not have the same status under CERCLA as do ARARs." Although not enforceable requirements, these documents are important sources of information that the regulatory agencies may consider during selection of the remedy, especially regarding the evaluation of public health and environmental risks, or which will be referred to, as appropriate, in selecting and developing cleanup actions [40 CFR § 300.400(g)(3), 40 CFR § 300.415(I)].

<u>State Regulations</u>

State requirements are potential ARARs for CERCLA response actions as long as they meet the following eligibility criteria:

- State law or regulation
- Environmental or facility siting law or regulation
- Promulgated (of general applicability and legally enforceable)
- Substantive (not procedural or administrative)
- More stringent than federal requirements
- Identified in a timely manner
- Consistently applied

Many state requirements listed as ARARs are promulgated with identical or nearly identical requirements to federal law pursuant to delegated environmental programs administered by federal agencies and the state.

<u>Types of ARARs</u>

There are three primary types of ARARs: chemical-specific, location-specific, and action-specific. An ARAR can be one or a combination of all three types.

Chemical-specific requirements address chemical or physical characteristics of compounds or substances at sites. These values establish acceptable amounts or concentrations of contaminants that may be found in, or discharged to, the ambient environment.

Location-specific requirements are restrictions placed on the concentrations of hazardous substances or the conduct of cleanup activities, because they are in specific locations. Location-specific ARARs relate to the geographical or physical positions of sites rather than the nature of contaminants at sites.

Action-specific requirements are usually technology-based or activity-based requirements, or limitations on actions taken with respect to hazardous substances, pollutants, or contaminants. A given cleanup activity will trigger an action-specific requirement. Such requirements do not themselves determine the cleanup alternative but define how chosen cleanup methods should be performed.

ARAR Waivers

CERCLA Section 121(d)(4) authorizes that any ARAR may be waived per one of the following six conditions if the protection of human health and the environment is ensured:

- It is part of a total remedial action that will attain such level or standard of control when completed (i.e., interim action waiver).
- Compliance with the ARAR at a given site will result in greater risk to human health and the environment than alternative options that do not comply with the ARAR.
- Compliance with such a requirement is technically impracticable from an engineering perspective.
- The remedial action will attain a standard or performance equivalent to that required by the ARAR through use of another method or approach.
- The ARAR in question is a state standard and the state has not consistently applied (or demonstrated the intention to consistently apply) the ARAR in similar circumstances at other sites.
- In meeting the ARAR, the selected remedial action will not ensure a balance between the need for protection of public health and welfare and the environment at the site and the availability of Superfund monies to respond to other facilities.

CERCLA Permit Exemption

CERCLA Section 121(e)(1), 42 United States Code (U.S.C). § 9621(e)(1), states, “No Federal, State, or local permit shall be required for the portion of any removal or remedial action conducted entirely onsite, where such remedial action is selected and carried out in compliance with this section.” The onsite activities must, however, comply with substantive permit requirements. The term “onsite” is defined in the NCP as “the areal extent of contamination and all suitable areas in very close proximity to the contamination necessary for implementation of the response action” (40 CFR § 300.5).

Simplot conducted a preliminary identification of potential ARARs (chemical-specific, location-specific, and action-specific) as presented in the RI/FS Work Plan (Formation 2011a). This analysis has been refined relative to findings of the RI and risk assessments and the scope of potential actions to be performed. A summary of potential ARARs and TBCs are presented in Tables 3-1 and 3-2.

As discussed in Section 3.4, a process to modify the aquatic water quality standard is underway and it is possible that a new standard will be adopted by the time the ROD is signed or shortly thereafter.

3.3 Remedial Action Objectives

This section presents the RAOs to address the key environmental issues described in Section 3.1 and the evaluation of ARARs in Section 3.2. The RAOs specify COCs and environmental media of concern, exposure routes and receptors, and are intended to provide protection of human health and the environment. In the RAOs, and throughout the document, the term "unacceptable risk" for human health is defined as greater than 1E-6 cancer risk and HQs greater than 1, or for ingestion of groundwater with arsenic or selenium concentrations greater than MCLs.

Groundwater

- Prevent future use of alluvial or Wells Formation groundwater with arsenic or selenium concentrations above MCLs as a drinking water source.
- Reduce or eliminate concentrations of arsenic and selenium in contaminated Wells Formation and alluvial groundwater to below MCLs within a reasonable time frame given the circumstances of the Site.[1]
- Reduce or eliminate loading of selenium from groundwater to surface water so that it does not result in concentrations that represent an unacceptable risk to aquatic life in the lower Sage Creek and Crow Creek watersheds.
- Reduce or eliminate loading of selenium from groundwater to surface water so that it does not result in concentrations above the Aquatic Water Quality Standard in the lower Sage Creek and Crow Creek watersheds.
- Reduce or eliminate concentrations of selenium and manganese in groundwater utilized for stock watering to acceptable levels

Soils, Overburden and Vegetation

- Reduce or eliminate unacceptable risks to future Seasonal Ranchers from ingestion of beef as the primary contributor of cancer risk, due to arsenic concentrations (calculated on a Sitewide basis) for soil.
- Reduce or eliminate unacceptable risks to terrestrial biota from soil and vegetation with elevated selenium concentrations on overburden or backfilled pits and external ODAs with minimal or no covers and in overburden seep/riparian areas downgradient of ODAs.
- Reduce or eliminate unacceptable risks to livestock from exposure to vegetation on ODAs and in associated seeps with levels of selenium that pose an acute and chronic risk.

[1] The detailed analysis will provide an evaluation of the predicted future changes in selenium concentrations in groundwater at key locations (and changes in concentration and load at the springs complex) for the No Further Action alternative and the different action alternatives. This evaluation will provide the basis for establishing a "reasonable time frame".

Surface Water

- o Reduce or eliminate unacceptable risks to human receptors from ingestion of non-regulated surface water (seeps and detention ponds) due to arsenic.
- o Reduce selenium concentrations in lower Sage Creek and Crow Creek watersheds to below levels that pose unacceptable risks for aquatic life.
- o Reduce selenium concentrations in lower Sage Creek and Crow Creek watersheds to below the Aquatic Water Quality Standard.
- o Reduce or eliminate unacceptable risks to livestock from exposure to water in seeps or detention basins with selenium concentrations that would represent a risk.

3.4 Preliminary Remediation Goals

PRGs specify quantifiable goals for COCs in environmental media to address the RAOs. Remedial action implemented for the purpose of meeting PRGs usually results in attainment of RAOs. A summary of the PRGs is provided in Table 3-3.

Regulated Surface Water: Site-Specific Selenium Criterion

Elevated selenium concentrations in Hoopes Spring, lower Sage Creek, and lower Crow Creek pose unacceptable risks for aquatic life. The aquatic water quality standard of 5 µg/L is applicable for surface water and applies to all locations within the watershed. In recent years, the national surface water quality criterion for selenium has been undergoing extensive revision (e.g., 2014 Draft Peer Review document, 2015 Draft Aquatic Life Criterion release, and the 2016 Final Aquatic Life Criterion release). The selenium aquatic life criterion will differ from most criteria derivation processes because it is based on effects relative to tissue concentrations in fish due to exposure through diet.

As described in Section 2.5.2, the current state of the science indicates that selenium concentrations in egg/ovary tissues from fish and other aquatic organisms provide the best measure of effects for aquatic life. Therefore, to support application for a site-specific selenium standard for Sage Creek and Crow Creek downstream of the Smoky Canyon Mine, Simplot conducted studies on developmental toxicity for brown trout using trout and trout eggs collected from the Site. The studies included literature review, field collection of environmental data from the watershed and other areas (starting in 2006), and laboratory reproduction studies with wild and hatchery trout species.

The trout reproduction studies conducted by Simplot have received extensive peer review and scrutiny. The site-specific selenium criterion (SSSC) Work Group, spearheaded by the IDEQ (and including representatives from USEPA headquarters, USEPA Region 10, Idaho Department of Fish and Game [IDFG], Forest Service, and Wyoming Department of

Environmental Quality [WDEQ]), provided valuable input into the planning and development of the field and laboratory studies. Results from the studies conducted by Simplot were used to develop an SSSC, based on survival of brown trout fry, which was provided to IDEQ via a proposal and technical support document released in 2012 (Formation 2012d).

While Simplot was developing the SSSC proposal, USEPA prepared a Revised National Criterion for Selenium based on fish tissue residues in egg/ovaries, which utilized data collected by Simplot at the Site. In 2016, USEPA released a Final National Criterion for selenium (USEPA 2016). The criterion utilizes data collected by Simplot as well as numerous other studies and proposes a tissue-based value for selenium using maternal transfer studies where adult fish were exposed and passed on selenium to developing eggs.

USEPA's 2016 Final National Criterion for selenium provides the most current and easily accessible compendium of reviews, different interpretations, and various effects thresholds derived using Simplot's Brown Trout Study data. Furthermore, it provides summary information for all of the other studies utilized in the derivation of the 2016 Final National Criterion. However, the Final National Criterion is not site-specific as it incorporates information from numerous sites and fish species (including white sturgeon and bluegill sunfish, two species not found in southeast Idaho). Simplot's SSSC studies utilizing brown trout are directly applicable to the Site conditions and thus provide the best information on effects of selenium to a sensitive fish species for this Site. Simplot is in the process of resubmitting an SSSC proposal to IDEQ which will go into rulemaking at the same time that IDEQ looks at adopting the 2016 National Criterion for other parts of the State. Simplot's SSSC is applicable and most representative of the Site conditions. When the SSSC is adopted as the standard for the Site by IDEQ, it will supersede the current standard for lower Sage Creek and lower Crow Creek to the Wyoming border. The current Idaho water quality standard will be applied until IDEQ and USEPA adopt Simplot's proposed SSSC for the Smoky Canyon Mine. The current standard would still apply in Wyoming.

In the Smoky SSERA (Formation 2015b), Simplot evaluated risk to aquatic receptors using a range of exposure concentration (EC10) values for selenium in egg tissues. The range included EC10 values developed by USEPA and by Simplot. In the 2016 Final National Criterion, USEPA elected to use only the survival (hatch to swim up) endpoint which resulted in a value of 21 mg/kg dw egg selenium. Using USEPA's approach to derive a combined endpoint, Simplot developed a survival endpoint (hatch to test termination) resulting in a value of 20.5 mg/kg dw egg selenium. Whole body tissue-based thresholds were developed for the Site based on the egg EC10 values cited above.

To translate from egg to whole body, USEPA used simple ratios of selenium concentrations in egg to selenium concentrations in the adult tissue. A median ratio for all of the individual data points was 1.45 (this translator is the ratio of egg selenium to whole body selenium, using data presented in Appendix B of the USEPA 2016 National Criterion). However, despite how they approached all of the other species, USEPA chose a single no-effect value associated with the egg concentration of 20.5 mg/kg dw as the whole body concentration for brown trout (13.2 mg/kg dw). Using the more standardized approach utilized throughout the 2016 Final National Criterion, the whole body concentration would be 14.14 mg/kg dw based on an egg value of 20.5 mg/kg dw.

As a slightly conservative measure, the egg threshold effect value for the Site based on brown trout should be 20.5 mg/kg dw (this value is slightly less than the USEPA-derived EC10 of 21 mg/kg dw for egg selenium). For whole body, the tissue value should be 14.14 mg/kg dw based on using a translator or conversion factor of 1.45 and an egg value of 20.5 mg/kg dw. This is the risk-based level that is protective of Site-specific conditions, based on Site data and associated ecological risk analysis. This PRG would also apply to Hoopes Spring, lower Sage Creek, South Fork Sage Creek, and lower Crow Creek.

Groundwater

The primary goals for groundwater are based on the selenium (0.05 mg/L) and arsenic (0.01 mg/L) MCLs. These levels have been developed to protect the aquifer or drinking water source and to protect human health. In addition, the SSLRA identified the potential for future risk from selenium to livestock due to stock watering. The SSLRA used a range of selenium concentrations from 50 µg/L to 300 µg/L to estimate potential exposure. The PRG is set at the low end of this range: 50 µg/L selenium. These PRGs apply on a point-by-point basis.

Non-Regulated Surface Water

The RAO for livestock potentially affected by elevated selenium in water in seeps or detention basins focuses on prevention of livestock exposure to water in seeps or detention basins with selenium concentrations that would represent an unacceptable risk. The SSLRA evaluated potential exposure scenarios and found that because of the relatively small exposure area (seep and detention basin), acute risks were of concern for livestock if they drink water with selenium concentrations greater than 0.314 mg/L. This applies to water at the Pole Canyon ODA seep (LP-1), Panel D seep (DS-7) and the detention basin (DP-7) downgradient of Panel D. The PRG applies to each seep or detention basin.

The SSHHRA also identified potentially unacceptable risks to humans from drinking water in seep areas or from detention ponds. The PRG for this pathway was set at the drinking water MCL for arsenic (0.01 mg/L), applicable at each seep or detention basin.

Soils, Overburden, and Vegetation

Estimated potential risks to wildlife populations from exposure on Panels A and D were mainly from the potential for selenium to accumulate in vegetation or invertebrates. Risks of impact from chronic selenium exposure to wide-ranging species such as deer, elk, coyotes, and raptors is relatively low because these species feed over wide areas and would be exposed to soils and vegetation on the panels for short periods. Impacts from acute exposure are possible if animals feed in areas of exceptionally high selenium concentrations on the ODAs. However, unacceptable risk to overall populations is small because (1) a relatively small proportion of the overall population would be affected, and (2) wildlife do not appear to be as susceptible to acute selenium exposure as livestock, possibly because of greater tolerance, but likely also due to behavioral avoidance of high selenium forage (Pfister et al. 2013).

Segments of populations of smaller-bodied wildlife such as rodents and songbirds may experience more chronic exposure to soils and vegetation on the mine panels. Risk of adverse effects from selenium exposure is greater for the individuals that spend most or all of their time on the mine panels. However, although uncertain, risk to overall Site populations is low because most of the Site and adjacent areas are not affected by mine disturbances and contain natural selenium concentrations.

Technical analysis to support the PRGs for soils and vegetation are provided in Appendix A. Per that analysis PRGs are as follows:

- 10 mg/kg average selenium concentration in vegetation as a Site-wide average to provide protection for chronic exposures;
- 50 mg/kg selenium in vegetation on a point-by-point basis to provide protection from acute exposures; and
- 137 mg/kg average selenium concentration in soils on a mine panel by mine panel basis.

For livestock, the SSLRA identified the potential for acute risks for selenium concentrations above 50 mg/kg in vegetation. A question has been raised related to whether a lower value would be appropriate based on observation of blind staggers. Until recently, two types of chronic selenium poisoning were discussed in the literature: alkali disease and blind staggers. Blind staggers is no longer believed to be caused by selenium but by sulfate toxicity due to consumption of high-sulfate alkali water and/or high sulfur-containing forages. Excess sulfate (>1% of diet) leads to polioencephalomalacia and the classical signs of blind staggers. Animals consuming milk vetch (*Astragalus bisulcatus*) have demonstrated clinical signs similar to those of blind staggers. Although milk vetch contains high levels of selenium, evidence now indicates that the alkaloid swainsonine in milk vetch is responsible for locoism and produces the neurologic clinical signs (Hall 2016). Based on this, the PRG for acute exposure for livestock is set at 50 mg/kg selenium in vegetation, consistent with the SSLRA. Also, per the findings of

Hall (2016), the PRG for chronic exposure for livestock is set at 5 mg/kg selenium in vegetation as an average value over a grazing allotment.

The RAO for ingestion of beef at the Site focuses on prevention of unacceptable risks to future Seasonal Ranchers due to arsenic concentrations in surface soil (calculated on a Site-wide basis). Section 6.2.1 of the Smoky SSHHRA described the estimated risks to seasonal ranchers from ingestion of beef. The background arsenic concentration in soils was estimated at 11.5 mg/kg (MWH 2015), as also presented in the Smoky SSHHRA (Formation 2015a). The 95UCL for arsenic concentrations in soil were 5.6 mg/kg on private lands and 16.2 mg/kg Site-wide. The highest upper-bound estimates of average concentrations were on the uncovered ODAs, on Panel A Area 2 (27.5 mg/kg) and D Panel (14.7 mg/kg). Based on the risk estimation approach and the Site data, a PRG of 11.5 mg/kg mean arsenic concentrations for the Site-wide concentration has been established.

4.0 IDENTIFICATION AND SCREENING OF GENERAL RESPONSE ACTIONS, REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

This section identifies GRAs, remedial technologies, and process options that are potentially implementable to address the RAOs identified in Section 3 for the contaminated media and exposure pathways of concern. GRAs are general categories of remedial activities (e.g. no action, institutional controls, containment, source controls, flow controls and routing, removal/disposal, and treatment) that may be used, either singly or in combination, to satisfy RAOs. Remedial technologies and process options are more specific applications of the GRAs.

This section presents the screening of GRAs, remedial technologies, and process options in accordance with the NCP to retain representative technologies and process options that can be assembled into remedial alternatives, which are discussed in Section 5.

The identification and screening process consists of the following general steps:

- Identify the contaminants and affected environmental media that pose risks to human health and the environment and group these into a category or categories of contaminated media for FS evaluation.
- Develop GRAs for the contaminated environmental media that will satisfy the RAOs.
- Compile remedial technologies and process options for each GRA that are potentially viable for remediation of the contaminated environmental media.
- Screen the remedial technologies and process options with respect to technical implementability for the contaminated media at the site. Technologies and process options that are not technically implementable relative to the contaminated media are eliminated from further consideration in this FS.
- Evaluate and screen the retained remedial technologies and process options with respect to effectiveness, ease of implementability, and relative cost. Technologies and process options that have low effectiveness, low implementability, or high cost to address the contaminated media are eliminated from further consideration in this FS.
- Combine and assemble the retained technologies and process options for the contaminated media into remedial alternatives as presented in Section 5.

The remainder of this section describes the contaminated media and evaluates GRAs, technologies, and process options that are potentially viable for addressing them to meet the RAOs and ARARs discussed in Section 3.

4.1 Contaminants and Affected Media

Selenium is the primary contaminant of interest in solid media, which includes soils and overburden in backfilled pits and external ODAs. The weathered shales in the overburden material are susceptible to leaching as water from rain and snowmelt infiltrates through these materials. Backfilled pits and external ODAs with minimal or no covers allow infiltration and subsequent releases of selenium and other COCs to Wells Formation groundwater. As shown in Table 4-1, the principal sources of selenium and other COCs to groundwater are: Panel A Area 2 and External ODA; and Panel D and External ODA. These are also the areas with limited covers that contain selenium and other COCs in surface soils and vegetation at levels representing a potential acute risk to ecological receptors and to livestock.

The contaminants of interest in aqueous media, which include groundwater and surface water in springs, are selenium and arsenic. Seepage generated within ODAs is discharged as surface seeps or migrates downward to the Wells Formation aquifer or the Sage Valley alluvial groundwater system. Wells Formation groundwater is transported to the springs complex where it discharges and is transported downstream to Sage Creek and Crow Creek. Groundwater may also be extracted from wells at the Site.

The extent of groundwater with selenium concentrations above the MCL is illustrated in Figure 3-1. Because of the complex fractured flow system in the Wells Formation aquifer at the Site it is not possible to make an accurate estimate of area and volume of groundwater with selenium concentrations above the MCL. Groundwater discharges at the springs complex, where the typical flows are in the range of 14 cfs. Selenium loading from the springs results in concentrations above the aquatic water quality standard for selenium in South Fork Sage Creek springs, Sage Creek, and Crow Creek. There are also seeps and detention basins downgradient of the ODAs with elevated selenium concentrations that pose potential risks to livestock (LP-1, DP-7, and DS-7). Some of these same seeps and detention basins have elevated arsenic concentrations that pose potential future risks to human receptors (LP-1, DP-7, DS-7, and EP-2).

4.2 General Response Actions

GRAs describe those actions that alone, or in combination, may be applied to areas of concern. GRAs are used to organize and structure potential remedial actions and are divided into remedial technology groups consisting of specific process options. This section identifies and describes the GRAs that may satisfy the RAOs presented in Section 3.

As described above, there are two media of concern within the Site: solid and aqueous. The solid media category includes contaminated soils and overburden in backfilled pits and overburden areas (referred to as solids and soils), and any residual solid material remaining after treatment. The aqueous media category includes groundwater and surface water. GRAs and remedial technologies have not been developed for the air medium because airborne transport of contaminants is an incomplete pathway (Formation 2015a, 2015b, 2016a).

The GRAs identified for the Site are:

- No Action
- Institutional Controls
- Access Controls
- Containment
- Source Control, Flow Control and Routing
- Removal and Disposal
- Treatment

The remedial technologies and process options associated with these GRAs are shown in Figure 4-1. GRAs and remedial technologies are briefly described in Section 4.3. More detailed descriptions of remedial technologies and process options and the results of the initial screening process for technical implementability are provided in Section 4.4 and Figure 4-2.

4.3 Identification of Remedial Technologies and Process Options

Remedial options are generally grouped by how they minimize contaminant release, contaminant transport, or risks associated with contaminants. Source control and containment remedial options reduce the release and/or transport of selenium and other COCs from the ODAs. Removal remedial options remove and dispose of waste material, contaminated soil, and or contaminated surface water and groundwater. Treatment remedial options are applied to reduce concentrations of selenium and other COCs in impacted surface water and groundwater. Institutional controls limit the potential for human activities to result in exposure to impacted media (e.g., water, soil, and vegetation). Access controls may be used to prevent access to source areas. In practice, it will take a combination of remedial options from all of these groups to effectively minimize the impact and risk associated with the ODAs.

This section describes typical approaches and methods that can be used to control selenium releases from overburden and available treatment technologies for removing selenium and other COCs from impacted waters.

4.3.1 No Action

The No Action GRA is required by the NCP as a baseline for comparison; however, because early actions have been implemented at the Pole Canyon ODA, this alternative becomes No Further Action.

Two NTCRAs were implemented at the Pole Canyon ODA to divert Pole Canyon Creek stream flow around the ODA, prevent run-on to the ODA from the northern hillside slope, and reduce or eliminate infiltration into the ODA. Under the No Further Action GRA, the operations and maintenance (O&M) activities for the NTCRAs would continue as required by the Settlement Agreements (USFS, USEPA and IDEQ 2006; USFS, IDEQ, and Tribes 2013). Water treatment at the pilot treatability study at the springs complex would be terminated.

4.3.2 Institutional Controls

Institutional controls are non-engineering mechanisms that provide the means by which federal, state and local governments or private parties can prevent or limit access to or use of contaminated environmental media, the use of areas impacted by contaminants, and/or to provide for the integrity and maintenance of engineered remedial components. The NCP emphasizes that institutional controls are meant to supplement engineering controls and may be a necessary component of the selected remedy. The NCP also cautions against the use of institutional controls as the sole remedy unless active response measures are determined to be impracticable. The USEPA recognizes four types of institutional controls (1) government controls, (2) proprietary controls, (3) enforcement and permit tools, and (4) information devices (USEPA 2000a, 2012). Institutional controls may be applied on a stand-alone basis or implemented in conjunction with other response actions as part of an overall remedy.

4.3.3 Access Controls

Access controls are physical barriers to limit access to source areas. Physical barriers may include fences and gates. Fences and gates are fixed structures that function as boundaries, barriers, or other means of security. Access controls may be temporary or permanent and may be implemented as separate, unconnected technologies or applied along with other remedial technologies as part of an overall remedy.

4.3.4 Containment

The containment GRA includes technologies and process options resulting in the physical containment or isolation of source areas to limit exposure and reduce the transport of selenium and other COCs. Containment technologies include (1) engineered covers, (2) barriers, and (3) sediment control features. Long-term maintenance requirements, including periodic inspection and monitoring, may be required for containment options.

4.3.5 Source Control, Flow Control and Routing

The source control GRA consists of active measures to manage sources and reduce the flow of water to source areas and subsequent release of selenium and other COCs into surrounding soils, groundwater, and surface water. Source controls include surface controls and slope stabilization. Grading, vegetation, and erosion protection are examples of source controls. Slope stabilization includes reducing slope grades and constructing retaining walls. At the Site, this GRA may be implemented alone or combined with other actions.

The flow control and routing GRA applies to surface water and consists of diversion via open channels or closed conduits. Flow control and routing has already been implemented by the 2006 NTCRA where Pole Canyon Creek flow is collected above the Pole Canyon ODA and piped to the valley below the ODA. An infiltration basin, installed just uphill from the ODA, allows any creek water from below the pipeline diversion to infiltrate before reaching the ODA. A run-on control ditch was also installed on the uphill side of the ODA. These actions prevent water from contacting ODA material and subsequently mobilizing selenium and other COCs. Other actions that have been implemented at the Site are routing and collection of ODA seeps and stormwater runoff in detention ponds, and installation of ditches to convey stormwater away from source materials. Additional flow control and routing actions may be implemented along with other actions.

4.3.6 Removal and Disposal

This GRA involves the removal and disposal of solid or aqueous media with concentrations of selenium or other COCs exceeding specified action levels or standards. Several technologies and process options exist within the removal GRA for remediation of overburden solids and soils and groundwater and surface water at the Site. Removal technologies include excavation of solids and collection of surface water or groundwater using extraction wells or trenches. Disposal technologies involve onsite consolidation, onsite or offsite disposal of treatment residuals and/or other solids, and onsite or offsite discharge of groundwater and/or surface water. This GRA is often combined with other GRAs such as institutional controls, containment, flow control and routing, or treatment. Long-term maintenance requirements, including periodic inspection and monitoring, may be required for removal options.

4.3.7 Treatment

This section presents the ex-situ and in-situ treatment options evaluated for groundwater and surface water and for solids and soils at Smoky Canyon Mine.

4.3.7.1 Ex-Situ Treatment

Ex-situ treatment technologies are remediation options where the affected medium is removed from its original location for processing.

Groundwater and Surface Water

Physical treatment methods involve removing contaminants from water without chemically altering them. These methods typically employ processes such as separation (mechanical, gravity and media filtration), or demineralization (ion exchange, reverse osmosis, ultrafiltration, and electrodialysis). Physical treatment may be applied on a stand-alone basis or implemented in conjunction with other treatment technologies.

Chemical treatment involves processes where contaminants are altered or precipitated from solution. Most chemical treatment methods have a secondary waste stream that requires further treatment and disposal. Chemical treatment methods included for initial screening are adsorption (activated carbon and metal oxide), solvent extraction, chemical precipitation, and oxidation/reduction.

Biological reduction removes inorganic constituents by reducing oxidized forms to elemental forms, which are typically less mobile and easier to precipitate out of water. For organic constituents, microbial activities can transform organic components to intermediate products and basic constituents such as carbon dioxide and water.

Thermal treatment is the process of applying energy to the water being treated to evaporate clean water, while leaving behind contaminants in a concentrated brine. Thermal treatment methods considered include mechanical evaporation and wet air oxidation.

Solids and Soils

Physical treatment technologies reduce the mobility or toxicity of contaminants, or reduce the volume by changing the physical properties of the materials (by lowering moisture content, increasing density, and/or reducing permeability). Physical treatment methods evaluated include stabilization/fixation, dewatering, and separation.

Thermal treatment technologies involve the application of energy to catalyze reactions that immobilize or detoxify inorganic compounds, or destroy organic compounds by oxidation or separation by distillation or volatilization. Process options considered are incineration and desorption.

Chemical treatment promotes reactions that convert contaminants into less hazardous compounds. Chemical treatment process options included in the initial screening are oxidation/reduction, hydrolysis, and chemical extraction.

Biological treatment of solids and soils consists of enhancing the biological degradation or reduction of contaminants by microorganisms. Biological treatment, including land farming, is typically implemented by creating favorable conditions for native microbial activity.

4.3.7.2 In-Situ Treatment

In-situ treatment technologies are process options designed to remediate media within soil or groundwater matrices without removing those matrices from the ground.

<u>Groundwater</u>

Chemicals are directly injected into the impacted region of the aquifer to treat the groundwater. The injected chemical agent interacts with the constituents in the groundwater plume to neutralize, precipitate, immobilize, fixate, or destroy the contaminants.

In-situ biological treatment of groundwater uses the same principle as ex-situ biological treatment, which consists of enhancing the conditions in the aquifer to reduce contaminants by microbial activity. This is typically achieved by injecting nutrients to preferentially favor the microorganisms that can degrade or reduce the target contaminants.

<u>Solids and Soils</u>

In-situ physical/chemical treatment technologies include stabilization/fixation and aeration. Stabilization/fixation is performed by using special machinery to directly inject stabilizing agents, such as cement, into the soil. Types of equipment used to deliver the stabilization agents into soils include rotary injection augers, jet grouting, and pressure grouting. Aeration of soils is typically achieved by soil vapor extraction.

Thermal treatment technologies involve the application of thermal energy to catalyze reactions that immobilize or detoxify inorganic contaminants, or destroy organic compounds by oxidation or separation by distillation or volatilization. Thermal treatments evaluated include vitrification and desorption.

In-situ biological treatment of solids uses the same principles as ex-situ biological treatment, except that the solids are not removed and are treated in place. Nutrients are injected into the solids and soils to encourage favorable microbial growth. Biological process options evaluated include enhanced biodegradation and phytoremediation.

4.4 Screening of Remedial Technologies and Process Options for Technical Implementability

The remedial technologies and process options identified in Figure 4-1 and described in Section 4.3 were screened based on technical implementability. A wide range of potential remedial technologies and process options were reviewed to evaluate the suitability for addressing residual overburden materials and impacted groundwater and surface water. A given technology or process option was eliminated from further consideration on the basis of technical implementability if site conditions or site characterization data indicated that the technology or process option is incompatible with the COCs or cannot be implemented effectively because of physical limits or constraints. A summary of the initial screening of remedial technologies and associated process options in terms of technical implementability is presented in Figure 4-2. Process options eliminated from further evaluation are shaded gray.

4.4.1 No Action

The No Action GRA is required by the NCP as a baseline for comparison and is therefore retained for further evaluation. The No Action GRA is not divided into technologies and process options. Because previous work has occurred at Smoky Canyon, this alternative becomes a No Further Action alternative. NTCRAs that have already been implemented would continue. Pilot treatability studies would be terminated.

4.4.2 Institutional Controls

Institutional controls are administrative and legal mechanisms that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action. They may be used alone or in conjunction with other alternatives as part of an overall remedy. Institutional controls are meant to supplement engineering controls during all phases of cleanup and may be a necessary component of the selected remedy.

Four types of institutional controls are evaluated (1) government controls, (2) proprietary controls, (3) enforcement and permit tools, and (4) information devices.

Government controls are usually implemented and enforced by a state or local government and may include zoning restrictions, forest closure orders, grazing controls, ordinances, statutes, building permits, or other provisions that restrict land or resource use. Forest closure orders can be used to prevent access to areas on National Forest System land. The Forest Service administers several grazing allotments that encompass portions of the Site. Land managers use grazing management plans as tools to protect water quality, forage, and beneficial use. Traditionally, grazing control is the practice of managing forage harvest levels by cows, horses, and sheep, so that the plant cover and community composition are maintained and erosion and sedimentation are not accelerated. Grazing controls may include guidelines for the duration of grazing, the type of livestock allowed to graze on the area, salt/mineral supplement requirements during grazing, and timing of grazing to reduce the risk to livestock. Grazing controls are often included as a BMP temporarily during implementation of the final remedy. Government controls such as zoning restrictions and forest closure orders that restrict land use or prevent access are potentially implementable and are retained for further evaluation. Controlling domestic livestock grazing would allow establishment of vegetation on recently seeded areas and is retained for further consideration.

Proprietary controls are property-use restrictions based on private property law and may include deed restrictions, easements, or covenants. Deed restrictions are rules and regulations that govern one or more parcels of land. They are recorded with the county and are permanent and "run with the land," so they bind all current and future owners of the parcel(s). In the case of land owned by Simplot, these proprietary controls may be used to prevent future use of alluvial or Wells Formation groundwater with arsenic or selenium concentrations above MCLs as a drinking water source, and prevent future stock watering using groundwater with selenium at levels that would represent an unacceptable risk. Deed restrictions are viable for use at the Site and are retained for further evaluation.

Enforcement and permit tools are legal tools such as administrative orders, federal facility agreements, and consent decrees that limit certain activities or require the performance of specific activities such as monitoring or reporting on effectiveness. These legal tools may be issued unilaterally or negotiated and are legally binding and can be enforced. Enforcement and permit tools are viable for use at the Site and are retained for further evaluation.

Information devices provide information or notification that residual or covered contamination may remain at a site. Such tools take a variety of forms and may include signs, deed notices, public information programs, grazing instructions, and state registries of contaminated sites. Signs convey information on land use or land-use restrictions; materials used to produce the sign must last for the length of time that the warning will be posted. The Forest Service has posted a notification/warning sign on Smoky Canyon Mine Road. In the future, the Forest Service may elect to post warnings signs to inform the public about the overburden material buried at the Site. Grazing annual operating instructions can be used to inform grazing permittees that residual contamination may remain at a site. Although information devices as an institutional control are not enforceable, signs, public information programs and grazing instructions are potentially implementable for use at the Site and are retained for further evaluation.

4.4.3 Access Controls

Access controls are physical barriers such as fences and gates to limit access to source areas at a site (e.g., ODAs or seeps or springs). Fences are listed as BMPs for phosphate mining in southeastern Idaho (Montgomery Watson 2000).

Fences and gates are fixed structures that function as boundaries, barriers, or other means of security. Fencing off a reclaimed/revegetated area can limit the uptake of selenium and other COCs by grazing livestock and wildlife and prevent damage to the area while vegetation is becoming established. By fencing off areas with vegetation high in selenium and other COCs or water sources high in selenium and other COCs, the impact to grazing livestock and wildlife can be reduced. The type of fence can vary from a three-strand barbed wire to a game-exclusion fence depending on the objective of implementing this access control. However, fences/gates should not be thought of as stand-alone controls, rather they should be implemented in conjunction with source controls. Fences and gates must be adequately maintained. Portions of the Pole Canyon ODA were fenced prior to construction of the NTCRA. Additional fencing may be considered to limit livestock access to seeps and/or at ODAs as part of the long-term remedy. Physical barriers such as fences and gates are potentially implementable and are retained for further evaluation.

4.4.4 Containment

Several technologies and process options within the containment GRA are identified and considered for solid media and groundwater and surface water that exceed standards or action levels. This GRA consists of containment measures to prevent or limit exposure to impacted media rather than treatment of the media. Some of the technologies are applicable to both overburden solids and soils and groundwater and surface water while others are applicable specifically to either solids/soils or groundwater/surface water. These technologies and process options can be used alone or in conjunction with surface control and flow control and routing technologies and process options.

4.4.4.1 Engineered Covers

Engineered covers are commonly used to prevent direct contact with seleniferous materials and to reduce infiltration and erosion, thereby reducing the release of selenium and arsenic that may potentially impact groundwater and surface water. Covers have already been used extensively at the Site for post-mining reclamation. Engineered covers are therefore applicable to overburden solids/soils, but may also provide benefits for groundwater and surface water. There are a variety of available engineered cover designs.

Various cover types, as well as encapsulation of seleniferous material, are discussed in the Selenium Management Practices document (Interagency/Phosphate Industry Selenium Working Group [SeWG] 2005). General design requirements for engineered covers include impedance of liquid migration through the solid media, maintenance requirements, sufficient drainage, resistance to damage by settling or subsidence, with a permeability lower than or equal to the underlying natural soils. Simplot identified source areas and available volumes of the primary material types to be evaluated for use in CERCLA cover systems (i.e., soil, tailings, Rex Chert and limestone gravel, and Dinwoody Formation material) that are considered for the FS (Formation 2016b). These cover systems are described below.

<u>Soil Cover</u>

A soil cover can provide a physical barrier between the vegetation root zone and ODA materials, thus reducing the potential for selenium uptake by selenium-accumulating plants along with preventing direct contact and ingestion by potential receptors. Of particular interest in semi-arid environments is the use of a cover designed to store rainwater and release it via evapotranspiration through the vegetative cover. It can also reduce infiltration of precipitation into the underlying overburden materials. The soil cover is potentially implementable and is retained for further evaluation.

<u>Tailings Cover</u>

As described in the Cover System Pilot Study Memorandum (Formation 2014b), Site-specific physical and chemical data for tailings indicate that tailings material is likely to be suitable for use in ODA covers. Two tailings impoundments, Tailings Pond No. 1 (TP-1) and Tailings Pond No. 2 (TP-2) are adjacent to the Site. Several million cubic yards of tailings are available in the impoundments and approximately 500,000 dry tons are generated each year by ongoing mining operations. Tailings material can provide a physical barrier between the vegetation root zone and ODA materials, thus reducing the potential for selenium uptake by selenium-accumulating plants along with preventing direct contact and ingestion by potential receptors.

The physical properties of Smoky Canyon tailings were evaluated in recent geotechnical testing as part of the Dairy Syncline planning process (Golder 2013). Based on the results, a minimum saturated hydraulic conductivity of 10^{-5} centimeters per second (cm/s) was estimated. This is in the range of hydraulic conductivity of Dinwoody Formation material measured at the Site. The Tailings Revegetation Field-Scale Pilot Study was a 5-year study that was performed near the Smoky Canyon tailings impoundments (Formation 2013c), and investigated plant uptake of selenium and the performance of tailings as a growth medium. This study found that seeded vegetation can establish and grow on tailings material, with or without amendments, and selenium uptake into plants is low. The results show that uptake of selenium by plants growing on tailings would not be an ecological risk issue. Tailings material is potentially implementable for use as a single-layer cover and as a component of a multiple-layer cover system, and is retained for further evaluation.

Rex Chert/Limestone Cover

Rex Chert/limestone barriers are used as BMPs in current phosphate mining in southeastern Idaho (Montgomery Watson 2000). When installed directly above the ROM overburden, chert/limestone provides a capillary break, or an additional thickness of non-seleniferous overburden within the cover profile to prevent vegetation from rooting in overburden materials higher in selenium and other COCs (i.e. center waste shale), and to prevent vegetative uptake and potential risk to grazing or foraging animals. Additionally, the coarse texture and corresponding low water-holding capacity result in unfavorable conditions for root advancement through the chert/limestone and into the overburden. Chert may also help prevent small mammals from burrowing into the overburden material. A capillary break layer can provide lateral drainage, which can improve the long-term stability of the cover. Rex Chert/limestone is available from ongoing mining operations, and has a generally coarse composition dominated by gravels with some sands and few fines.

Potential use of chert/limestone for cover material was evaluated as part of the EE/CA process for the Pole Canyon NTCRA (Formation 2012a). Due to the coarse textural composition, chert/limestone is unfavorable as a growth medium (i.e., would not support vegetation growth) without additional amendments; if used alone as a surface cover material, chert/limestone would actually result in increased infiltration compared with the existing overburden due to its high saturated hydraulic conductivity. Therefore, use of chert/limestone was considered only as a layer between the growth medium and ROM overburden or as a water conveyance layer in a more complex cover system (i.e. geosynthetic clay liner [GCL], Dinwoody or tailings). In this position in the cover system, the thickness of the chert/limestone cover does little to influence the amount of net percolation into the underlying overburden. Therefore, the thickness of chert/limestone should be determined based on its function as a barrier or its water conveyance performance. The rate of generation and availability of chert/limestone from active mining operations is a key factor in the scope and timing of implementation. The chert/limestone cover is potentially implementable, is a proven, effective material, and is retained for further evaluation.

Dinwoody Cover

Dinwoody Formation material is well suited for use in cover systems at the Site. It is a locally available material that can be easily accessed in areas near the backfilled pits and external ODAs. Although there is some variability in the composition and material properties of the Dinwoody Formation at the Site, it is generally comprised of interbedded siltstone, shale, and limestone that grade into a calcareous shale and siltstone with depth. Typically, Dinwoody is a poorly-graded, fine-textured material with a low saturated hydraulic conductivity and a high moisture storage capacity. The gradation and texture of Dinwoody provide a growth medium that supports vegetation, and the low saturated hydraulic conductivity of the Dinwoody reduces net infiltration.

The effectiveness of using Dinwoody for cover systems has been demonstrated on Panel E (Formation 2012a), where it has provided stable reclamation surfaces and resulted in successful growth of vegetation. Dinwoody material was also used as part of the cover system for the 2013 NTCRA on the Pole Canyon ODA. The NTCRA included minor grading of the ODA, placement of a 2-foot-thick chert/limestone cover overlain by a 3-foot-thick Dinwoody cover, installation of stormwater runoff controls, and revegetation with non-selenium-accumulating species. The Dinwoody cover is potentially implementable, is a proven, effective material, and is retained as a cover option.

Water Balance Cover

The water balance cover relies on temporary storage of snow melt and rain water in soil near the surface coupled with removal of stored water by evaporation and transpiration (Albright et al. 2009). The store-and-release mechanism relies on an integrated system of soil, plants, and atmosphere, and is used for managing the water balance and for maintaining percolation below a desired threshold. The water balance cover is typically a monolithic design constructed of 4 to 10 feet of fine-textured soil (e.g., sandy silt) and vegetated with local grasses. Some water balance covers may include a layer of coarse material under the fine-textured soil as a capillary barrier. Actual cover thickness is calculated based on the required storage using the water content of the soil material at field capacity and the wilting point, determined from the soil water characteristic curve. Water balance covers have been tested in field demonstration projects at sites with different climates as part of USEPA’s Alternative Cover Assessment Program (ACAP) (Albright et al. 2009). The water balance cover is potentially implementable and is retained for further evaluation.

Geosynthetic Covers

Geosynthetic covers consist of multiple layers and may include a geomembrane (GM) or a GCL. A GCL is a woven fabric-like material that incorporates a bentonite or other clay, which has a very low hydraulic conductivity. A geosynthetic clay laminate liner (GCLL) includes a layer of bentonite clay inserted between two geotextile layers. The top geotextile layer is laminated with a polyethylene geomembrane layer, providing an additional layer of protection against desiccation and ion exchange degradation. If a low permeability cover such as a GM or GCL is used, an overlying natural or geosynthetic drainage layer must be placed just below the soil or rock cover and the closure slope generally needs to be flatter than 3:1 to achieve stability of the cover over the geosynthetic materials. If a GM is selected, it must have high internal shear strength to provide stability on side slopes steeper than 5:1. For side slopes of 3:1, additional anchoring of the geosynthetic is required and angular gravel or rock is required above a geotextile for stability of this layer. The use of a geosynthetic cover is potentially implementable and is retained as a possible cover technology.

4.4.4.2 Barriers

Vertical barriers may be used to control migration of contaminants in groundwater. Low permeability cutoff walls or diversions may be installed below ground to contain, capture, or redirect groundwater flow.

Slurry Walls

Slurry walls are the most common subsurface barriers because they use conventional technology and are an effective means of reducing groundwater flow in unconsolidated earth materials. A slurry wall is constructed by blending a soil mixture with a bentonite slurry and placing the mixture in a vertical trench to form a low permeability barrier wall. In some cases, the trench is excavated under a slurry of cement, bentonite, and water, and this mixture is left in the trench to harden. Slurry walls are not feasible at the Site due to the number of sources and depth of the Wells Formation aquifer and the extent of slurry walls that would be required to control groundwater flow. Slurry walls are not implementable and therefore are not retained.

Sheet Piling

Sheet piling may be used to form a physical groundwater barrier. Sheet piles are made of wood, synthetic materials, pre-cast concrete or steel. Concrete is used primarily where great strength is required. Steel is often the most effective form of sheet pile cutoff. However, interlocks between barrier panels may be difficult to seal. Sheet piling is not feasible at the Site due to the number of sources and the depth of the Wells Formation aquifer and the extent of sheet piling that would be necessary to control groundwater flow. Sheet piling is not implementable and is not retained.

Rock Grouting

Rock grouting or grout curtains are subsurface barriers created in fractured or unconsolidated materials by pressure injection of a low permeability grout mixture. The vibrating beam method, where grout is placed in the void left from the retreat of a previously driven pile, is most often used to place grout to generate a wall in unconsolidated soils. Pressure injection of grout and grout placement using the vibrating beam method are not feasible because of the extent required to control groundwater flow and the depth of the Wells Formation aquifer. Rock grouting is not implementable and is not retained.

4.4.4.3 Sediment Control Features

Sediment control features may be used to reduce or eliminate loading of sediment in a stream or to minimize the movement of sediments already in the channel. Process options for the sediment control remedial technology include dikes or berms and detention basins. Within the Site, such sediment controls are applicable only to stormwater runoff, and would not be appropriate for use in various drainages where containment process options (e.g., rock covers) would be more effective in terms of controlling sediment mobilization.

Dikes/Berms

Dikes and/or berms consist of grading and reshaping the surface of the land in order to manage surface water infiltration and runoff while controlling erosion. Dikes and berms must be blended with surrounding undisturbed ground to provide a smooth transition in topography. Dikes and berms have been implemented at the Site and are potentially implementable for future actions and are retained for further evaluation.

Detention Basins

Detention basins, also termed sedimentation basins or ponds, detain stormwater runoff allowing sediments to settle out of the water. Detention basins have been shown to be moderately to highly effective in settling and removing sediment and moderately effective at minimizing contaminant volume. Detention basins have been applied as BMPs at several of the external ODAs at the Site. Detention basins are implementable and are retained for further evaluation.

4.4.5 Source Control, Flow Control and Routing

Source control, flow control and routing GRAs consist of active measures to effectively manage source materials (e.g., overburden solids/soils) and groundwater and surface water contact (flow volume, velocity, and direction) with those source materials. In particular, these technologies limit the transport of COCs to surface water. Source control, flow control and routing may be used as stand-alone technologies or in conjunction with other technologies.

4.4.5.1 Surface Controls

Surface control process options considered for use at the Site include grading, erosion control and protection, and vegetation. These process options are applicable to overburden solids/soils, but may also provide benefits for groundwater and surface water by reducing/eliminating releases of selenium from soils/overburden into groundwater or surface water. Any land surface alterations associated with surface controls must be blended with surrounding undisturbed ground to provide a smooth transition in topography.

Grading

Grading is the general term for techniques used to reshape the surface of the land in order to manage surface water infiltration and runoff while controlling erosion, thereby providing both source control for overburden solids/soils and flow control for groundwater and surface water. The general equipment and methods used in grading are conventional technologies, readily available and essentially the same for all surfaces. However, specific applications of grading technology will vary by site. Grading is often conducted in conjunction with surface preparation practices and revegetation as part of an integrated site remediation, which includes other actions such as containment. Grading is implementable and is retained for use in conjunction with other technologies.

Erosion Control and Protection

Erosion protection consists of the use of erosion-resistant materials such as riprap, vegetation, and geosynthetic fabrics to reduce or eliminate erosion of solid media by stormwater runoff. These materials are often installed after regrading of the surface has been performed. Erosion protection uses conventional equipment and materials. Erosion-control fabrics can promote vegetation by retaining moisture and protecting the seedlings during germination. Maintenance requirements for these erosion protection measures are minimal. Erosion protection is suitable for dry mine waste (i.e., overburden), impacted surface soils, and impacted subsurface soils above the water table. This process option can be used with other technologies or as a stand-alone technology. Erosion control protection is implementable and is retained for further evaluation.

Vegetation

Establishing a vegetative cover is a standard surface reclamation technology for backfilled pits and external ODAs. In addition to stabilizing surface materials by reducing erosion potential, the vegetation increases evapotranspiration (ET) at the surface and reduces water infiltration into overburden and subsequent release of selenium and other COCs. The 2006 Smoky Canyon Mine EE/CA (NewFields 2006) suggested that infiltration may be decreased by as much as 50% by establishing a well-vegetated cover on poorly vegetated overburden. Although this 50% reduction was not determined from modeling, it was applied to several alternatives to roughly estimate the potential benefits of establishing a good vegetative cover. Planting of native species that have low affinity for selenium uptake may be effective in reducing potential risks to grazing livestock and ecological receptors. Vegetation also improves aesthetics. Previous response actions at the Pole Canyon ODA have demonstrated the effectiveness and implementability of revegetation measures in conjunction with containment/covers (Formation 2006, 2012a). Vegetation is implementable and is retained for further evaluation in conjunction with engineered cover process options.

4.4.5.2 Slope Stabilization

Slope stabilization technology includes slope reduction and retaining walls to reduce erosion and sediment transport. Slope stabilization process options are often used in combination with other technologies or process options in source control/containment and flow control/routing GRAs. Slope stabilization is applicable to overburden solids/soils.

Slope Reduction

Slope reduction consists of flattening or reducing the grade of the surface slopes of areas of concern including backfilled pits and external ODAs. This slows stormwater runoff velocity, limits erosion, promotes vegetation, and reduces the potential for slope failure. Slope reduction is implementable and is retained for further evaluation.

Retaining Walls

Retaining walls may be used with grading/slope reduction to stabilize steep soil slopes by reducing the effective slope of an earthen surface. Retaining walls are rigid vertical or near vertical structures of steel beams and sheets, concrete, masonry blocks, wood, rock, or other materials capable of withstanding the structural forces imparted by the soil on the uphill face of the wall. This process option is constructed using conventional techniques. Retaining walls are potentially implementable and are retained for further evaluation for use in ODA cover construction if needed to stabilize slopes.

4.4.5.3 Diversion

Diversion consists of routing or managing flow within open channels or closed conduits, and is applicable to surface water, specifically stormwater. Flows can be diverted to open surface water bodies, sedimentation basins, or treatment systems. Diversion ditches and stream alteration are listed as BMPs for phosphate mining in southeastern Idaho (Montgomery Watson 2000) and discussed in the Selenium Management Practices document (SeWG 2005).

Diversion ditches can be used to prevent “clean” surface water from coming in contact with the overburden in a disposal area. Additionally, diversion ditches can be constructed on an ODA to manage runoff in such a manner as to limit infiltration and resultant leaching. This remedial technology limits the release of selenium and other COCs from overburden and migration from the ODA to nearby surface water or groundwater. Diversion ditches are effective if they are adequately designed and maintained. At the Site, diversion ditches would be effective upgradient of certain backfilled pits and external ODAs to reduce clean surface water run-on from the adjacent slopes by diverting it into existing creeks. They may also be used on long ODA slopes to shuttle water off the overburden.

Stream alterations can be used to limit the “clean” water that comes in contact with overburden. This is accomplished by diverting the natural stream channel away from an ODA or backfilled pit using closed conduits (e.g., culverts/piping), infiltration basins, and/or construction of a new stream channel that mimics the natural stream features in the area. Permits must typically be obtained from both the Idaho Department of Water Resources and the Army Corps of Engineers prior to implementation. Although under CERCLA the need for such permits is waived, the substantive requirements must still be met. Stream alterations are effective if they are adequately designed and maintained. Stream alteration was used as a component of the NTCRA for the Pole Canyon ODA.

Open Channels

Open channels are engineered canals or ditches constructed for the purpose of collecting and conveying surface water. Constructed conventionally by excavating and shaping the ground surface, open channels are usually lined with vegetation, riprap, or concrete, as necessary and appropriate for the anticipated flows, channel dimensions and gradient, to prevent erosion by surface water. These channels are constructed with engineered grades and side slopes for specifically designed flow volumes and velocities, and may also be used to manage groundwater flow after collection. Open channels are potentially implementable and are retained for further evaluation.

Closed Conduits

Closed conduits also provide a means to manage and control surface water. Closed conduits usually consist of culverts or pipes and are typically constructed of high-density polyethylene plastic, polyvinyl chloride plastic, corrugated metal, steel, or concrete depending on the engineering requirements. Often used for conveying flow on steeper grades, where space is limited or infrastructure encroaches, closed conduits minimize or eliminate erosion of surface soils. Closed conduits must be maintained to ensure proper operation. Similar to open channels, closed conduits can also be used to route groundwater flow after collection. Closed conduits are potentially implementable and are retained as a process option for further evaluation.

4.4.6 Removal and Disposal

Remedial technologies for the removal and disposal GRA for overburden solids and soils and groundwater include excavation of solids and soils, collection of groundwater using extraction wells or trenches, and disposal or consolidation either onsite or offsite.

4.4.6.1 Excavation

Excavation involves physical removal and transport of solid materials from one location to another. This technology can be combined with technologies or process options from other GRAs such as containment, treatment, or disposal. Conventional excavation involves the use of earthmoving equipment (backhoes, trackhoes, scrapers, front-end loaders, and/or bulldozers) to dig, scrape or push materials that require treatment, relocation, or contouring. Conventional excavation could be used for removal of overburden solids/waste rock materials and soils/sediments from ODAs or detention basins, or for contouring an area prior to construction of a cover system. The removed materials would be further treated, consolidated, placed under a cap or used in the construction of a cover system. Excavation could be easily implemented for excavation and consolidation of solid materials (waste rock) or excavation and reuse of soils as part of the remedial action and is retained as a process option for further evaluation.

4.4.6.2 Collection

Process options for collection of groundwater include extraction wells and interception trenches. Once collected, the groundwater may be either treated or disposed.

<u>Extraction Wells</u>

Extraction wells can typically be used to capture groundwater and control gradients and flow direction. Wells are constructed with conventional drilling equipment and materials. Extraction wells create a local groundwater sink that causes flow towards the well. Once extracted, the groundwater can be routed and managed as necessary. Multiple extraction wells could be installed along preferential pathways and along the West Sage Valley Branch Fault. Extracted groundwater could be treated and discharged or reintroduced.

The RI, however, demonstrated that groundwater flow within the Wells Formation is influenced by preferential flow paths. In fact, placement of a Wells Formation well within zones of high transmissivity and high concentrations of COCs is difficult. Monitoring wells GW-18 and GW-24 are examples. These Wells Formation monitoring wells were placed near the West Sage Valley Branch Fault and downgradient of the Pole Canyon ODA and Panel E, respectively. The Wells Formation at GW-24 is low transmissivity while GW-18 is in a high transmissivity zone. Concentrations of selenium in groundwater samples collected from GW-18 and GW-24 are below the MCL for selenium. Moreover, GW-18 is located less than 700 feet upgradient of Hoopes Spring where maximum observed selenium concentration is approximately 10 times observations at GW-18. The presence of preferential flow paths was further demonstrated by the range of observed selenium concentrations from discrete springs sampled at Hoopes Springs during the RI.

In short, use of extraction wells upgradient of Hoopes Springs is unlikely to be effective due to known hydrogeologic complexities. Moreover, Hoopes Springs acts as a regional groundwater discharge feature, which effectively captures the migration of COCs within Wells Formation groundwater in the southern groundwater flow system.

Extraction from pumping wells, similar to the Culinary Well and the Industrial Well, could be implemented and is retained as a process option for further evaluation.

Trenches

Interception trenches are excavated ditches or channels used to collect, control, and manage groundwater flow. The trenches are excavated to a depth greater than the groundwater table and are either maintained as open trenches or filled with permeable material such as riprap, drain rock, or drainage pipe. Groundwater flows toward and is intercepted by the trench. The trench can be designed to control the level of the water in the vicinity of the trench. Once in the trench, the water may be managed and routed as necessary. Both closed (gravel-filled or pipe) or open trenches are effective for collection of groundwater in low permeability soils with shallow groundwater tables. Due to the complex geology at the Site, deep Wells Formation groundwater that has been impacted by releases from ODAs flows along preferential pathways and along the West Sage Valley Branch Fault and discharges at Hoopes Spring and South Fork Sage Creek springs. Because most of the groundwater at the Site is in the deep Wells Formation aquifer, collection trenches are not implementable and are not retained as a process option for groundwater collection.

4.4.6.3 Solids Disposal

Disposal process options available for solid media include onsite disposal at a repository, onsite consolidation with other mine wastes, or offsite disposal at a disposal facility.

Onsite Disposal

Onsite disposal of excavated solid media would require an agency-approved location for a repository. Onsite disposal would limit or prevent the movement of selenium and other COCs and is considered to be a suitable process option for removal and disposal of solids/soils and treatment residuals. Onsite disposal is potentially implementable and is retained for further evaluation.

Onsite Consolidation

Consolidating overburden can limit the water in flow, the oxygen in flux, and the uptake by vegetation thus limiting the impact to surface water, groundwater, grazing livestock, and wildlife.

By consolidating material into one disposal area, there can be an overall reduction in surface area available for infiltration of precipitation and leaching of contaminants, while also providing an environment within the disposal area that is more conducive to lower oxidation rates. Onsite consolidation of small volumes of nonhazardous treatment residuals from the treatment systems (e.g., sludge from the fluidized bed bioreactor system or spent media from a passive treatment system) in backfilled pits could minimize leaching of selenium and other COCs from external disposal areas. Onsite consolidation of larger volumes of overburden material by backfilling pits and reclaiming slopes would be beneficial to reduce the overall footprint of waste materials. Onsite consolidation is potentially implementable, as long as the disposal setting is suitable to prevent remobilization of COCs into the environment, and is retained for further evaluation.

Offsite Disposal

Excavated solid media may be disposed of offsite. Offsite disposal requires excavating the impacted solid media and transporting the media to an appropriate disposal facility. Although not generally required for mine wastes, pretreatment of mine wastes that exceed Resource Conservation and Recovery Act (RCRA) toxicity criteria, based on the toxicity characteristic leaching procedure (TCLP) test (EPA Method 1311) would be required prior to disposal in a hazardous waste landfill. Offsite disposal would reduce the volume of waste material and is considered to be a suitable process option for all solid media. Offsite disposal is potentially implementable and is retained for further evaluation.

4.4.6.4 Groundwater/Surface Water Disposal

Disposal options for groundwater or surface water include injection or conveyance and discharge to an appropriate treatment facility.

Injection

Injection wells may be used for disposal of impacted groundwater or surface water by injecting water into wells drilled into the subsurface. Groundwater at the Site occurs in alluvium and in Wells Formation bedrock. Because the valley-fill alluvial groundwater flow system discharges to surface water in Sage Creek, injection of groundwater into this system would not result in disposal and would not be feasible. Similarly, because the Wells Formation aquifer discharges at the springs complex, injected groundwater would be transported to this area, and therefore, would not be disposed. Injection of groundwater would not be feasible. Neither of these hydrogeologic units provides an appropriate situation where large quantities of water could be injected for disposal. Aqueous injection is therefore not retained for further evaluation.

<u>Discharge to Treatment Facility</u>

Impacted groundwater or surface water may also be transported to a publicly owned treatment works or a dedicated treatment facility at the Site. There are no publicly owned treatment works in the vicinity of the Site, therefore, this option is not implementable and is not retained. Discharge to an onsite treatment facility is potentially implementable in conjunction with treatment technologies and is retained for further evaluation.

4.4.7 Treatment

4.4.7.1 Ex-Situ Treatment

This section provides more detailed information about the ex-situ treatment options evaluated, along with a preliminary screening of each technology.

<u>Groundwater and Surface Water</u>

Separation

Gravity – Gravity separation involves settling of suspended solids in ponds, basins, or tanks, with or without aid of baffles or other devices. Gravity settling typically results in sludge with a solids content of 30% to 40% by weight. The technology would not remove dissolved selenium, and is not considered as a viable stand-alone treatment. However, gravity separation is potentially implementable in conjunction with other technologies that generate suspended solids and is retained for further evaluation.

Mechanical – Mechanical separation is a process to remove solids from liquids. Mechanical separation is achieved using devices such as belt presses, filter presses, and vacuum filtration units. These devices can attain up to about 70% solids concentration depending on the nature of the solids to be removed. Mechanical separation would not address the dissolved selenium in water at the Site, but would potentially be implementable for dewatering waste streams from other treatment technologies and is retained for further evaluation.

Media Filtration – Media filtration is a separation process which uses granular material (typically, anthracite coal and/or sand) through which influent water flows. Suspended solids are trapped on top and within the filter bed, while effluent is collected in an underdrain. As suspended particles collect in the filter media, they block the drain pores, reducing the filter effectiveness. The collected solids are rinsed out periodically by reversing the direction of the flow through the media (backwashing). Like the other physical separation processes, media filtration would not be an effective stand-alone process, but is potentially implementable and is retained for consideration in conjunction with other technologies.

Demineralization

Reverse Osmosis – Reverse osmosis is a physical treatment process in which pressurized water passes through a semipermeable membrane. The applied pressure to the waste stream is greater than the osmotic pressure of the feed water. As water passes through the membrane, dissolved constituents in the water are concentrated on the feed side of the membrane to form the waste brine and a dilute product water on the permeate side of the membrane. The waste brine may be as much as 15% to 25% of the total feed water flow, and requires further handling and treatment. A treatability pilot study was conducted at Smoky Canyon Mine to evaluate the effectiveness of reverse osmosis to remove dissolved selenium and other constituents from Site waters (Formation 2011f). The selenium concentration in the influent water for the pilot study was 0.03 to 0.05 mg/L. Selenium in the “concentrate,” produced by the reverse osmosis unit, ranged from 0.14 to 0.20 mg/L. Selenium concentration in the “permeate” (effluent) from the reverse osmosis unit was effectively non-detect. The unit was capable of treating approximately 25 gallons per minute (gpm), with the concentrate comprising 5 gpm and the clean permeate being the remaining 20 gpm. The results of the study showed the system was highly effective at separating and concentrating the selenium. Reverse osmosis is considered a potentially implementable technology which would need to be combined with a technology that removes selenium from the aqueous concentrate stream and is retained for further evaluation.

Ultrafiltration – Ultrafiltration is a membrane-filtration technology similar to reverse osmosis; however, the pore size in the membrane is slightly larger than the pore size in the reverse osmosis membrane allowing monovalent ions (e.g., sodium, chloride, etc.) to pass through while rejecting multivalent ions (e.g., selenium, calcium, sulfate, etc.). The proportion of water that can be treated by ultrafiltration will vary depending on its chemical composition. Ultrafiltration is considered a potentially implementable treatment technology in conjunction with or as a substitute for reverse osmosis and is retained for further consideration.

Ion Exchange – Ion exchange is a treatment method in which cation or anion exchange resins are used to remove ions from water/wastewater. Ions held by electrostatic forces to charged function groups on the surface of the ion exchange resin are replaced by ions of similar charge in the water. Ion exchange resins are selected to preferentially remove specific ions from the feed water and replace them with highly soluble, nontoxic ions. Due to regeneration and rinsing requirements, the ion exchange process would result in waste materials, which would require further handling and treatment. Ion exchange is potentially implementable for selenium removal in conjunction with other processes and is retained for further evaluation.

Electrodialysis – Electrodialysis is a membrane process that employs an electric field as the driving force for separating a liquid influent into a concentrated stream and a depleted ("clean") stream. Cation exchange membranes permit only negatively charged ions to pass, while anion exchange membranes permit only positively charged ions to pass. Electrodialysis is typically used for low-flow-rate and high contaminant concentration wastewater treatment applications. While electrodialysis is effective in removing organic contaminants, it is not implementable for the removal of inorganic contaminants; therefore, it is not considered an appropriate treatment technology option and is not retained.

Adsorption

Activated Carbon – Carbon adsorption is a proven technology for the removal of organic constituents in water treatment systems. In the carbon adsorption process, water is contacted with the activated carbon in a series of packed bed columns. Although carbon adsorption is an effective method of removing organic constituents, it is only moderately effective for removal of inorganic constituents. Overall performance typically is related to water chemistry. While carbon adsorption may not be a standalone technology for selenium removal, the process is potentially implementable in conjunction with other technologies and is retained for further consideration.

Metal Oxide – Metal oxides such as zero-valent iron or activated alumina are capable of selective metal adsorption. As water flows through a bed of these materials, metal/metalloid ions (e.g., arsenic) are adsorbed by the surface of the iron or alumina particles in the bed. The process is pH dependent and results in a solid residue that may require further treatment and disposal. While metal oxide adsorption may not be a standalone technology, the process is potentially implementable in conjunction with other technologies and is retained for further consideration.

Chemical

Solvent Extraction – Solvent extraction is the separation of constituents from a liquid by contact with another, immiscible, liquid. Solvent extraction is effective on organic constituents, but is not a proven treatment method for inorganic constituent removal. Further research may be required. Solvent extraction is considered potentially implementable with additional research and is retained for further evaluation.

Chemical Precipitation – Chemical precipitation is a treatment method in which dissolved ions/salts are precipitated in the form of insoluble salts. Precipitation is caused by addition of chemicals to reach chemical saturation and/or vary the pH. The insoluble salts may be removed from the water by sedimentation, coagulation, and/or flocculation. Precipitation is considered potentially implementable for removal of selenium in conjunction with other treatment technologies and is retained for further evaluation.

Oxidation/Reduction – Chemical oxidation and reduction use agents such as oxidation, chlorination, hydrogen peroxide, and ultraviolet light to react with contaminants and oxidize them. Oxidizing agents are non-specific, and will react with any reducing agents present in the water to be treated. In some cases the reaction products have the potential to be more toxic than the original contaminants. Care must be taken when selecting the oxidizing agents to be used. Oxidation/reduction reactions have been demonstrated as an effective stand-alone process for treatment of organics and some inorganic compounds such as cyanides. Oxidation/reduction may improve the separation characteristics for removal of selenium if used in conjunction with other treatment technologies and is retained for further evaluation.

Biological

Biodegradation – Biological treatment involves the degradation or reduction of contaminants by microorganisms. Groundwater or surface water could be extracted or pumped to a process location (e.g., wetlands or anaerobic bioreactor) for treatment. Metals and other inorganic contaminants can be removed from the water using anaerobic bacteria that decrease the solubility via biological processes and then precipitated or absorbed by the media in the wetlands or bioreactor.

Two pilot scale biological treatment systems have been evaluated at the Site. The first system was a semi-passive, buried, anaerobic, bioreactor used to treat a low flow, high concentration seep (DS-7), which discharges to the surface at the eastern toe of the Panel D external ODA. Overburden material comprising this ODA was placed directly overlying a small stream channel during mining of Panel D (Formation 2014c). The ODA was covered with a partial topsoil and vegetative cover system in 2002. Seep DS-7 is likely the surface expression of water that infiltrates through the ODA, reaches the lower permeability material present at the ground surface beneath the ODA, and flows along the small channel. The seep is captured by detention basin DP-7 where the water either evaporates or infiltrates downward into underlying Wells Formation bedrock. The initial bioreactor vessel was amended with cheese whey, compost, and zero-valent iron to establish and maintain the appropriate environmental conditions for the targeted microorganisms. The pilot system operated for approximately 7 months and achieved a selenium removal efficiency between 72% and 97% (Moller 2002).

This pilot unit was refitted and used for about 2 years, from July 2013 to November 2015, for a semi-passive treatment pilot study. Overall, the treatment system achieved 56% removal of total selenium in seep water (Formation 2016d). The semi-passive biological treatment system is relatively easy to implement and can be installed, operated, and maintained using common materials and local feed source(s), but may need additional supplements to promote bacterial activity. Access to the pilot treatment system to adjust operational parameters to maintain treatment operation was difficult and potentially unsafe during the winter months because of the steep, snow-covered unimproved road leading to the seep and treatment system. Although the pilot treatment system was supposed to be semi-passive that required little or no maintenance, the system was more difficult to operate during the winter due to freezing within the bioreactors, and required significant maintenance during spring restart. Although this semi-passive system has moderate effectiveness for removing selenium and is difficult to implement in remote locations during the wintertime, it is retained for further evaluation.

The second biological treatment pilot study is a larger scale, active water treatment plant located between Hoopes Spring and South Fork Sage Creek Springs. The plant consists of an anaerobic fluidized bed bioreactor which contains media that hosts a film of bacteria that specifically target selenium for their biological metabolism. Start-up and troubleshooting for the first phase of the pilot study began in late 2014 and the system treated 200 gpm to 250 gpm of comingled flow from Hoopes Spring and South Fork Sage Creek Springs through early 2016 (Formation 2014d, 2017). The Phase 1 pilot study system has been operating since March 2016 and is ongoing. An ultrafiltration/reverse osmosis system and a second fluidized bed bioreactor unit will be added for Phase 2 in order to treat flows of 1,000 gpm to 2,000 gpm (Formation 2017). Initial data indicate that the active fluidized bed bioreactor is capable of achieving 80% to 90% removal.

Biological treatment of water at the Site is potentially implementable for removing selenium and other COCs from groundwater and surface water and is retained for further consideration.

Thermal

Mechanical Evaporation – Mechanical evaporation is a process in which water is heated to the boiling point. The water vapor is condensed to form condensate (distilled water), which is the product. The contaminants are concentrated in the water brine byproduct. Because of the large water flow rates at the Site, mechanical evaporation would not be implementable and is not retained for further consideration.

Wet Air Oxidation – Wet air oxidation is a combustion process that occurs in the liquid phase, by adding air at high pressure and elevated temperatures. The products of the reaction are water, nitrogen compounds, carbon dioxide, and an oxidized liquid stream. While the process is appropriate for destroying organic compounds, it is not implementable for inorganics; therefore, wet air oxidation is not a viable process option for the Site and is not retained.

Solids and Soils

Physical

Stabilization/Fixation – Stabilization/fixation is a technology in which inorganic or organic agents are added to impacted soil to reduce the solubility or mobility of contaminants. Ex-situ stabilization generally involves excavation of the solids, mechanical mixing of the solids with stabilizing agents, curing of the mass for optimal leach resistance and geotechnical properties, followed by onsite or offsite disposal of the stabilized mass. A variety of stabilization agents are available, including cement, fly ash, silica, bentonite, and various polymers. The types and combinations of stabilization agents that are effective for a particular waste depend on the chemical and physical characteristics of the solid. Stabilization/fixation may be applicable to smaller volumes of overburden used in the cover process to aid in immobilizing contaminants in the upper portions of the overburden. Stabilization/fixation is potentially implementable and is retained for further evaluation.

Dewatering – Dewatering is most effective for separating liquid and solid media for further treatment or disposal. Dewatering is not applicable for large volumes of overburden material; therefore this process option is not retained.

Separation – Physical separation is a process whereby soils are slurried and passed through a gravity separation process to extract inorganic constituents. This process is most effective where there is a significant difference in particle size, and the contaminants are present in a narrow range of sizes. It is also effective where free inorganic constituents are present and can be selectively removed. These conditions are not present at the Site. Physical separation is not implementable and is not retained.

Thermal

Incineration – Incineration is a process which effectively destroys organic compounds by applying sufficient energy to convert these compounds into nontoxic constituents (e.g., water and carbon dioxide). Incineration is not applicable for inorganic constituents such as selenium in solids and soils; therefore, this technology is not retained.

Desorption – Desorption is a process by which volatile compounds are separated or recovered from a solid matrix. These separation process options are effective for organic constituents, but are not effective for inorganic constituents. Desorption is not appropriate for use at the Site and is not retained.

Chemical

Oxidation/Reduction – Similar to the ex-situ treatment of water, oxidizing agents can be applied to solids and soils to react with contaminants reducing them to a less toxic or mobile form. The ex-situ version of this process is achieved by excavating the solids, and slurrying them in a reactor with the oxidizing agent. These reactions can be effective in detoxifying hazardous sludge containing both organics and inorganics. Common oxidizing agents used for sludge treatment include hydrogen peroxide, chlorine, and ozone. This treatment would not be applicable for treating contaminants as a stand-alone technology, but could be used in conjunction with other treatment options to reduce the toxicity of process solids. Oxidation/reduction is potentially implementable and is retained for further evaluation.

Hydrolysis – Hydrolysis is a process in which contaminants react with hydrolyzing agents such as mineral acids or alkaline solutions, resulting in the decomposition of the chemical compounds. It is widely used for treating organic wastes but is not feasible for removing selenium or other inorganic chemicals. Hydrolysis cannot be implemented technically and is not retained.

Extraction – Extraction is generally a multistage, counter current, intense scrubbing circuit in which contaminated soil or sludge is excavated/dredged, screened, attrition scrubbed, washed with a surfactant, and separated. The application of extraction has been demonstrated for soils contaminated with petroleum hydrocarbons and/or wood treating chemicals. Extraction is not a proven method for the treatment of inorganic constituents and further research may be required for those applications. Extraction is considered potentially implementable with additional research and is retained for further evaluation.

Biological

Enhanced Biodegradation – Biological treatment of solids and soils consists of enhancing the biological degradation of constituents by microorganisms. Ex-situ biological treatment is typically implemented by slurrying solids with the nutrient additives needed to create favorable conditions for the desired microbial activity. Biological treatment of solids has been proven to be most effective for the treatment of hydrocarbons and other organic constituents. The technology is not implementable for the removal, or fixation of inorganic constituents in solids, and is not an appropriate treatment option for solids at Smoky Canyon Mine. Therefore, enhanced biodegradation is not retained.

4.4.7.2 In-Situ Treatment

This section provides more detailed information about the in-situ treatment options being evaluated, and the preliminary screening of each technology for implementability.

Groundwater and Surface Water

Chemical

Chemical Injection – Chemical agents are directly injected into the impacted region of the aquifer to treat the groundwater. The injected chemical agent interacts with the constituents in the groundwater plume to neutralize, precipitate, immobilize, fixate, or destroy the contaminants. General limitations of this technology include the possibility of displacing chemicals to adjacent areas due to the added volume of the chemical solution, and the production of hazardous compounds by reaction of the injected agents with constituents other than the treatment target. Because of the Site conditions for groundwater (e.g., deep aquifer and fractured flow), and the properties of selenium and arsenic, chemical injection is not a viable technology for the Site and is eliminated from further consideration.

Biological

Biodegradation – In-situ biological treatment of groundwater uses similar scientific principles as ex-situ biological treatment, and is primarily achieved by enhancing conditions within the contaminated plume to favor native microorganisms that can metabolize the target contaminants. In most situations in-situ biodegradation is difficult to implement due to a lack of control for the key growth variables such as moisture, temperature, pH, and inorganic nutrients.

A subsurface semi-passive remedial technology is currently being tested by Monsanto at the toe of the Horseshoe ODA at the South Rasmussen mine. The current installation consists of an excavated trench that is backfilled with structural backfill material, a short term carbon source, and long term carbon source. The alluvial flow system in the area ranges between near surface to 20 bgs. Maximum trench depth is 20 feet. Silica sand is used as the structural backfill material, alfalfa is used as the short term carbon source, and wood chips are used as the long term carbon source. The three elements are mixed according to the design ratio (1:1:1) by the loader and are then deposited into the trench.

The design also includes installation of some conduit pipes that would allow for supplemental carbon sources to be added to the system, if needed.

In-situ biological treatment is applicable to inorganic constituents in groundwater, and is retained for further evaluation.

Solids and Soils

Physical

Stabilization/Fixation – In-situ stabilization/fixation is performed by using special machinery to directly inject stabilizing agents, such as cement, into the soil. Types of equipment used to deliver the stabilization agents into soils include rotary injection augers, jet grouting, and pressure grouting. In-situ stabilization and fixation has similar advantages and disadvantages to ex-situ treatments. Although stabilization/fixation may not be implementable for large volumes of overburden material, it may be applicable for immobilizing small volumes of material as part of the cover process and is retained for further consideration.

Aeration – Aeration of soils is typically achieved using soil vapor extraction systems. These systems apply a vacuum to subsurface wells to enhance the volatilization process for organic compounds. This treatment technology is not applicable to the inorganic contaminants at the Site, and is therefore not retained.

Thermal

Vitrification – Vitrification is a thermal treatment process that immobilizes inorganic compounds and destroys organic compounds by electrically heating and fusing the soil into a stable, glass-like block. Vitrification is potentially implementable and is retained for further consideration.

Desorption – Thermal desorption is similar to aeration, with the addition of a heat source to aid in the volatilization process. As previously discussed, this type of technology is not effective for the treatment of selenium or other inorganic constituents, and therefore, is not appropriate for use at the Site and is not retained.

Biological

Enhanced Biodegradation – In-situ biological treatment of solids uses the same principles as ex-situ biological treatment, except that the solids are not removed and are instead treated in place. It consists of enhancing the biological degradation or reduction of constituents by microorganisms. This process has not been demonstrated to be effective as a treatment for selenium or other inorganic constituents in soils; therefore, this technology is not appropriate for the Site and is not retained.

Phytoremediation – Phytoremediation involves the use of vegetation for the in-situ treatment of contaminated soils and sediments. Plants can directly uptake some organic and inorganic constituents, and accumulate them in the plant tissue. Due to the presence of grazing livestock and wildlife in the vicinity of the Site, phytoremediation would not be an appropriate technology and is not retained.

4.5 Evaluation of Remedial Technologies and Process Options for Effectiveness, Implementability, and Relative Cost

Each of the technically implementable remedial technologies and process options retained from the initial screening process presented in Section 4.4 were further evaluated to determine whether they should be eliminated from consideration or retained for assembly into remedial alternatives. Technologies or process options were qualitatively evaluated for effectiveness, implementability, and relative cost. The criteria used for this evaluation are as follows:

<u>Effectiveness</u>

Effectiveness of a remedial technology or process option is evaluated on the potential effectiveness in handling the estimated volume of solids/soil and groundwater/surface water and on meeting the objectives identified in the RAOs. Potential impacts to human health and the environment during construction and implementation are considered. The evaluation also considers whether or not the remedial technology or process option is proven effective for the conditions at the Site.

<u>Implementability</u>

Technically implementable remedial technologies and process options retained from the initial screening are evaluated for technical and administrative feasibility. Remedial technologies and process options that were clearly ineffective and were therefore not applicable or not feasible were eliminated during the initial screening. In this evaluation, implementability focuses on the ability to obtain permits for offsite remedial actions, administrative and institutional feasibility, the availability and capacity of treatment and disposal services, and the availability of necessary equipment and workers to implement the technology.

Relative Cost

Cost has a limited role in the screening of remedial technologies and process options. Relative capital and O&M costs are used rather than detailed cost estimates. The cost analysis is evaluated based on engineering judgment and is ranked relative to other process options (i.e., low, moderate, high cost) in the same remedial technology type. Because remedial alternatives and associated quantities are not defined during this screening evaluation, relative cost is provided qualitatively rather than quantitatively. The greatest differences in costs are generally associated with different technology types. Cost differences of different process options within a technology type are usually less significant.

Each of the remedial technologies and process options retained from the initial screening were evaluated against the three criteria to determine whether they should be eliminated from further consideration in the FS or retained for assembly into remedial alternatives. A summary of the results of the evaluation process are shown in Figure 4-3. Remedial technologies or process options with low effectiveness, low implementability, and/or relative high cost are eliminated from further consideration and are not used to develop remedial alternatives. These process options are shaded gray. The specific location where implementation of a retained process option is applicable is also considered during the evaluation and is briefly described. The screening is described in the following subsections.

4.5.1 No Further Action

The No Action alternative is required for consideration by the NCP and is retained. Because previous work has occurred at Smoky Canyon, this alternative is No Further Action.

4.5.2 Institutional Controls

Institutional controls are administrative and legal mechanisms that help to minimize the potential for exposure to contamination and/or protect the integrity of a response action. They may be used alone or in conjunction with other alternatives as part of an overall remedy and are meant to supplement engineering controls during all phases of cleanup and may be a necessary component of the selected remedy.

The land where mining activities have occurred at the Site (and where the source areas are located) is federal land managed by the Caribou-Targhee National Forest. As such, land-use controls such as Forest Service closure orders may be used by the Forest Service to prevent access to the Site or prevent activities that could compromise the integrity of remedial actions. The Forest Service administers several grazing allotments that encompass portions of the Site. Land managers use grazing management plans as tools to protect water quality, forage, and beneficial use. Grazing controls are often included as a BMP temporarily during implementation of the final remedy. Controlling domestic livestock grazing would allow establishment of vegetation on recently seeded areas. Land-use controls and grazing controls are easily implementable, would be effective at a relatively low cost, and are retained for the development of remedial alternatives.

Simplot owns the land in Sage Valley are therefore could implement deed restrictions to prevent future activities that would present a risk. Deed restrictions are easily implementable, would be effective at a relatively low cost, and are retained for development of remedial alternatives.

Enforcement and permit tools such as administrative orders, federal facility agreements, and consent decrees could be effective to limit certain activities or require the performance of specific activities such as monitoring or reporting on effectiveness. Administrative orders and consent decrees are legally binding and can be enforced at a relatively low cost. These enforcement options are retained for development of remedial alternatives.

Public information programs would be effective to restrict activities that could compromise remedial actions. For example, during the period that cover systems vegetation is maturing, it would be appropriate to inform the public that access is restricted until certain components of the remedy are complete. Signs could be an effective method of providing information. In the future, the Forest Service may elect to post warnings signs to inform the public about the residual contamination present at the Site. Grazing annual operating instructions could be used to inform grazing permittees that residual contamination may remain at the Site. Public information programs, warning signs, and grazing instructions are easily implementable institutional controls and would be moderately effective at a relatively low cost and are retained.

These process options are all retained for the development of remedial alternatives.

4.5.3 Access Controls

Access controls include physical barriers such as fences and gates to limit access to source areas at the Site (e.g., ODAs or seeps or springs). Fences are listed as a BMP for phosphate mining in southeastern Idaho (Montgomery Watson 2000).

These controls would be appropriate for preventing access during implementation of remedial actions and until they are effective. For example, fences could be used to restrict access to seeps and detention basins with selenium and arsenic concentrations above levels of concern would be effective while control of the sources is being implemented and until source control becomes effective (which will reduce concentrations in the seeps and detention basins).

Physical barrier process options are all retained for the development of remedial alternatives.

4.5.4 Containment

Various cover types, as well as encapsulation of seleniferous material, are discussed in the Selenium Management Practices document (SeWG 2005). Simplot identified source areas and available volumes of the primary material types to be evaluated for use in CERCLA cover systems that are considered for the FS (Formation 2016b).

Dinwoody covers have already been used extensively at the Site for post-mining reclamation. They are effective in preventing direct contact to overburden materials and in reducing infiltration of water (and thereby reducing the subsequent release of selenium and transport to soils, groundwater and surface water). The Pole Canyon ODA 2013 NTCRA entailed installation of a 3-foot thick Dinwoody cover underlain by a 2-foot thick layer of chert/limestone. This cover was selected for the NTCRA by an EE/CA evaluation which showed that it would be effective in protecting human health and the environment. In addition to being used as a thick barrier layer to prevent vegetation from rooting in overburden materials, chert/limestone could be used as a water conveyance layer in a more complex cover system (i.e. geosynthetic clay liner [GCL], Dinwoody or tailings). Dinwoody and chert/limestone covers are proven, effective materials, and are retained for the development of remedial alternatives.

Simplot also identified tailings as a potential component of an ODA cover system because of its low hydraulic conductivity and subsequent effectiveness in reducing infiltration into underlying overburden materials (Formation 2014b). Because the material could be highly-erodible on an ODA slope it is not implementable as a surface material, but could be used as a subsurface layer (for example beneath a chert/limestone layer that would provide physical protection and stability). A large quantity is readily available in the tailings impoundments and more is generated each year by active mining. Tailings material is retained for use as a subsurface layer in cover systems on ODAs.

Soil covers can provide a physical barrier between the vegetation root zone and ODA materials, thus reducing the potential for selenium uptake by selenium-accumulating plants along with preventing direct contact and ingestion by potential receptors. However, Dinwoody is present at the Site in large quantities, is proven effective, and can support vegetation in a similar manner to soil. Sufficient quantities of soil for ODA covers would be more difficult to obtain and have a higher cost (because of longer transportation distances). Because it is less effective, less implementable, and comes at a higher cost than Dinwoody material, a soil cover is screened out from further consideration in the FS.

Water balance covers tested in field demonstrations in semi-arid climates (e.g., Montana and Utah) are hydraulically equivalent to the geosynthetic cover (Albright et al. 2004). The monolithic soil storage layer is effective in storing and releasing snow melt and rain water and does not rely on the physical characteristics of a single design element (i.e., the low hydraulic conductivity barrier). Although the water balance cover is thicker than a soil or geosynthetic cover, soil placement methods are implementable and less labor intensive than construction of a hydraulic barrier layer or placement of a geomembrane, resulting in a lower relative cost. Because the water balance cover is effective and implementable, this process option is retained for the development of alternatives.

Geosynthetic covers consist of multiple layers and may include a GM or GCL. Other materials such as Dinwoody and chert/limestone would also be used in a GM/GCL cover to provide growth media for vegetation and stability/drainage. The GCL technology has been implemented successfully in the Southeast Idaho Phosphate Mining Resource Area: notably at South Maybe Canyon Mine (a CERCLA action on a cross-valley fill ODA) and at the Blackfoot Bridge Mine (as part of active mining). Therefore, this option is retained for the development of remedial alternatives.

Sediment control features such as dikes/berms and detention basins already in place at the Site are effective in preventing stormwater runoff from mining areas from reaching local creeks. These features would be maintained as needed. Additional features may be constructed to support installation and operation of new covers on Panel A and Panel D, and therefore, these process options are retained.

With the exception of soil covers, all engineered cover process options and sediment control features are retained for the development of remedial alternatives.

4.5.5 Source Control, Flow Control and Routing

Surface control process options considered for use at the Site include grading, erosion control and protection, and vegetation. Grading can be used during cover installation to provide a surface that promotes runoff and thus reduces infiltration. Grading will be needed for covers at Panel A and Panel D to eliminate areas where pooling of water currently occurs. Erosion protection consists of the use of erosion-resistant materials such as riprap, vegetation, and geosynthetic fabrics to reduce or eliminate erosion of solid media by stormwater runoff. These materials are usually installed after regrading of the surface has been performed and have been used at the Site. These process options will be used as necessary in the design of ODA cover systems. Establishing a vegetative cover is a standard surface reclamation technology for covers on backfilled pits and external ODAs and has been implemented successfully at the Site. Vegetation will be used at the surface of any cover system installed on ODAs.

Slope stabilization technology includes slope reduction (by grading) and retaining walls to reduce erosion and sediment transport. Both process options were used in the Pole Canyon ODA 2013 NTCRA and the option could be used in cover installation at other ODAs (to be determined during remedial design).

Diversion consists of routing or managing flow within open channels or closed conduits. This process option was used in the 2006 NTCRA at the Pole Canyon ODA to convey the flow in Pole Canyon Creek around the ODA. For future work, this process option may be used as part of the design of cover systems on the Panel A and Panel D ODAs to manage stormwater.

Source control, flow control and routing process options are all retained for the development of remedial alternatives.

4.5.6 Removal and Disposal

Remedial technologies for the removal and disposal GRA for overburden solids/soils include excavation of solids/soils, and disposal or consolidation either onsite or offsite. Technologies for removal and disposal of contaminated groundwater are limited to extraction wells and discharge to an onsite treatment facility.

Complete source removal is not implementable or effective for pit backfill and external ODAs. The material volume is large (millions to tens of millions of cubic yards) and no suitable location exists for disposal. Also, the resultant disposal area would have similar environmental conditions and issues as for the current pit backfill and ODAs. Similarly offsite disposal of large volumes of material would not be more effective than source control actions and would entail orders of magnitude higher cost.

However, source removal could be effective for small volumes of materials. For example once source controls (i.e., ODA covers) are implemented and are effective, residual sediment remaining in seep areas or stormwater/seep detention ponds could be removed and consolidated onsite. This could be an effective method to manage residual risk after source controls are complete. Similarly, residual solid materials generated by water treatment, could be consolidated onsite if their chemical properties were suitable. If the residual materials were characterized as hazardous waste, then the materials would require offsite disposal in a hazardous waste landfill.

Extraction wells could be used to capture groundwater and control gradients and flow direction. Multiple extraction wells could be installed along preferential pathways and along the West Sage Valley Branch Fault. Extracted groundwater could be treated and discharged or reintroduced. The RI, however, demonstrated that groundwater flow within the Wells Formation is influenced by preferential flow paths. In fact, placement of a Wells Formation well within zones of high transmissivity and high concentrations of COCs is difficult. Monitoring wells GW-18 and GW-24 are examples. These Wells Formation monitoring wells were placed near the West Sage Valley Branch Fault and downgradient of the Pole Canyon ODA and Panel E, respectively. The Wells Formation at GW-24 is low transmissivity while GW-18 is in a high transmissivity zone. Concentrations of selenium in groundwater samples collected from GW-18 and GW-24 are below the MCL for selenium. Moreover, GW-18 is located less than 700 feet upgradient of Hoopes Spring where maximum observed selenium concentration is approximately 10 times observations at GW-18. The presence of preferential flow paths was further demonstrated by the range of observed selenium concentrations from discrete springs sampled at Hoopes Springs during the RI.

In short, use of extraction wells upgradient of Hoopes Springs is unlikely to be effective due to known hydrogeologic complexities. Moreover, Hoopes Springs acts as a regional groundwater discharge feature, which effectively captures the migration of COCs within Wells Formation groundwater in the southern groundwater flow system. Extraction from pumping wells similar to the culinary well and the industrial well would be moderately effective and fairly easy to implement, but would have a relatively high cost. Extraction wells are retained as a technology for alternatives development.

Another retained process option for this remedial technology is routing groundwater that discharges at the springs complex to a water treatment facility. This is being implemented in the water treatment pilot study and additional conveyance systems may be installed to maintain the required influent flow and quality to any treatment system.

Removal and disposal technologies/process options retained for the development of remedial alternatives include excavation of solids/soils and disposal or consolidation onsite or disposal offsite, and extraction or routing of groundwater to an onsite treatment facility.

4.5.7 Treatment

Groundwater and Surface Water

The principal treatment technology for removing selenium is biological treatment. Two pilot scale biological treatment systems have been evaluated at the Site. The first system was a semi-passive, buried, anaerobic, bioreactor used to treat a low flow, high concentration toe seep (seep DS-7) from one of the ODAs. The initial pilot system operated for approximately 7 months and achieved a selenium removal efficiency between 72% and 97% (Moller 2002). This pilot unit was refitted in 2013 and used for about 2 years. Overall, the treatment system achieved a selenium removal efficiency of 56% (Formation 2016d). The system was supposed to be semi-passive with little maintenance required; however, it was more difficult to operate during the winter due to freezing within the bioreactors, and required significant maintenance during spring restart. Although this semi-passive system has moderate effectiveness for removing selenium and is difficult to implement in remote locations during the wintertime, it is retained for development of remedial alternatives because it is implementable for a low to moderate cost.

The second biological treatment pilot study is a larger scale, active water treatment plant, located between Hoopes Spring and South Fork Sage Creek Springs. The plant consists of an anaerobic fluidized bed bioreactor which contains media that hosts a film of bacteria that specifically target selenium for their biological metabolism. Phase 1 of the pilot study has been effectively operating since March 2016 and is ongoing. A second fluidized bed bioreactor unit will be added in conjunction with an ultrafiltration/reverse osmosis system for Phase 2 in order to treat higher flows (Formation 2017). Initial data indicate that the active fluidized bed bioreactor is capable of achieving 80% to 90% removal.

Other process options may be required to support the biological treatment system, as determined by design and operations testing. These include gravity separation (settling of suspended solids in ponds, basins, or tanks), mechanical separation (such as belt presses, filter presses, and vacuum filtration units), media filtration (typically using sand), reverse osmosis/ultrafiltration (separation of contaminants by semipermeable membrane), chemical precipitation (precipitation of dissolved ions/salts in the form of insoluble salts), and/or chemical oxidation or reduction to improve selenium removal efficiency. While these options are retained in the FS process, they are not stand-alone technologies, rather options to improve the selenium removal by the biological system.

Several process options evaluated for effectiveness, implementability, and relative cost were not retained for development of remedial alternatives in the FS including ion exchange, adsorption using activated carbon or metal oxides, and solvent extraction. Ion exchange was retained as a potentially implementable treatment technology. However, the process has not been tested in conditions similar to those found at the springs complex and due to uncertain effectiveness and relatively high cost, ion exchange is screened out of further consideration.

Carbon adsorption is implementable and is an effective method of removing organic constituents; however, it is only moderately effective for removal of low concentrations of arsenic, and is ineffective for the removal of selenium. Overall performance typically is related to water chemistry. While carbon adsorption may be potentially implementable, it has low to moderate effectiveness for inorganic contaminants and a relatively high cost. Therefore, carbon adsorption is not retained.

Metal oxides are capable of selective metal adsorption. A pilot scale study was performed at the Site to test the effectiveness of a zero-valent iron, metal oxide adsorption system (Formation 2012f). Zero-valent iron was selected over the more common activated alumina due to the potential for the iron media to more effectively remove selenium than the alumina. Selenium concentrations in the pilot influent ranged from 0.035 to 0.050 mg/L. The 24-gpm system only achieved an average selenium reduction of 40% to 50% (not sufficient to meet surface water quality criteria). This study demonstrated that the technology would not be effective at consistently reducing selenium concentrations to levels that would meet Site PRGs and is therefore not retained.

Biodegradation is retained for the development of remedial alternatives as a primary process option for treatment of groundwater and surface water.

<u>Solids and Soils</u>

In-situ or ex-situ stabilization/fixation involves injecting stabilizing agents, such as cement, into the soil or excavation and mechanical mixing of solids with stabilizing agents. While this process may not be implementable for large volumes of overburden material, it may be applicable for smaller volumes. Stabilization/fixation is implementable and could be effective for immobilizing small volumes of material as part of the cover process and is retained for development of remedial alternatives in conjunction with cover process options.

Oxidation/reduction is a process in which oxidizing agents are applied to solids and soils to react with contaminants reducing them to a less toxic or mobile form, and can be effective in detoxifying hazardous sludges containing both organics and inorganics. This treatment would not be applicable for treating contaminants as a stand-alone technology, but could be used in conjunction with other treatment options to reduce the toxicity of process solids and treatment residuals and is retained for development of remedial alternatives.

Extraction is implementable and is effective for removal of organic constituents from solids/soils, but is not a proven treatment method for inorganic constituent removal. Further research may be required, which would increase the relative cost of this technology. Using extraction on large volumes of overburden material would also result in higher relative costs. Extraction is not an appropriate process option and is not retained.

Vitrification is a thermal treatment process that immobilizes inorganic compounds in solids/soils. Although thermal vitrification could be effective, due to the large volumes of overburden present at the Site the process would have low implementability and relatively high costs; therefore, vitrification is not retained.

Physical stabilization/fixation and chemical oxidation/reduction are retained as process options for treatment of solids/soils for the development of remedial alternatives.

4.6 Retained GRAs, Remedial Technologies, and Process Options

Based on the results of the two-step screening process described in Sections 4.4 and 4.5, the remedial technologies and process options within each GRA that are retained for further evaluation and development of alternatives are summarized in Table 4-2. Various combinations of technologies and process options are assembled into remedial alternatives. The development and screening of alternatives is presented in Section 5.

5.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

In this section, remedial alternatives are assembled by combining the retained remedial technologies and process options. The primary objective of this phase of the FS is to develop an appropriate range of remedial alternatives that will protect human health and the environment and meet ARARs. These remedial alternatives are then screened using a qualitative process with standard evaluation to determine overall effectiveness, implementability, and cost. The purpose of the screening is to reduce the number of candidate alternatives to a smaller more manageable number, which are then analyzed more fully in the detailed analysis phase of the FS. The alternatives that have been developed are comprehensive, Sitewide alternatives, consistent with USEPA guidance.

5.1 Description of Remedial Alternatives

Sitewide remedial alternatives were assembled by combining the retained remedial technologies and process options that are capable of addressing contamination at the Site (see Table 4-2). The primary actions at the Site are source controls to reduce the release and transport of selenium and other COCs from ODA materials to groundwater and treatment of seeps and of groundwater discharging at the springs complex to reduce selenium concentrations in downgradient surface water.

Panel E is not included in the remedial alternatives because the existing cover (installed during post-mining reclamation) is sufficient to provide protection of terrestrial biota (see Figure 2-10) and is predicted to significantly reduce releases of selenium to groundwater to well below levels for Panels A and D (see Figure 2-6). Therefore remedial actions are not proposed at Panel E. Similarly, the NTCRAs performed at the Pole Canyon ODA are predicted to provide protection over time and no additional remedial action is proposed at that location.

The remedial alternatives identified for the Site are described below, and summarized in Table 5-1. Each of the action alternatives (different cover types on the ODAs) also has three different levels of treatment of groundwater discharging at the springs complex.

5.1.1 Alternative 1 - No Further Action

As previously described, two NTCRAs were implemented at the Pole Canyon ODA to divert Pole Canyon Creek stream flow around the ODA, prevent run-on to the ODA from the northern hillside slope, and reduce or eliminate infiltration into the ODA. Under the No Further Action alternative, O&M activities would continue per the NTCRA Consent Decrees. The water treatment pilot study at the springs complex would be terminated.

5.1.2 Alternative 2 – Barrier Covers

Under this alternative covers would be installed at Panel A Area 2 and at Panel D to prevent direct contact with overburden and to reduce levels of selenium in vegetation to below the 50 mg/kg PRG.

A field-scale pilot study being performed under CERCLA at the Conda Mine (Formation 2012e, 2016c) indicates that a 1-foot-thick chert/limestone capillary break layer overlain by a 1-foot-thick layer of Dinwoody material would be adequate to achieve the PRG and that cover configuration will be assumed for the purposes of this FS (field pilot study testing to support remedial design could be implemented to demonstrate similar performance at the Smoky Canyon Mine Site).

This alternative also contains the option for passive treatment at the LP-1 and DS-7 seeps. A subsurface semi-passive system has been tested at the Smoky Canyon Mine (see Section 4.5.7). A subsurface semi-passive remedial technology is also currently being tested by Monsanto at the toe of the Horseshoe ODA at the South Rasmussen mine. The current installation consists of an excavated trench that is backfilled with structural backfill material, a short-term carbon source, and a long-term carbon source. Silica sand is used as the structural backfill material, alfalfa is used as the short-term carbon source, and wood chips are used as the long-term carbon source. Concepts for passive treatment will be included in the detailed analysis.

As with the other action alternatives, three variants are identified related to treatment of groundwater discharging at the springs complex:

- Alternative 2a – no treatment;
- Alternative 2b – treatment of 2,000 gpm; and
- Alternative 2c – treatment of 3,000 gpm.

Alternative 2b would entail continued operation of the pilot treatment system at Hoopes Springs. The 2,000 gpm pilot system is scheduled to be operational by summer 2017. The primary treatment technology utilized is biological reduction, however, the other treatment process options retained by the screening in Section 4 (and shown in Table 4-2) are being used, or have the potential to be used, as unit processes within the overall treatment system. This is illustrated by the overall process flow diagram for the 2017 system illustrated in Figure 5-1 (reproduced from Stantec 2016). As shown the main unit processes are:

- Ultrafiltration;
- Reverse osmosis;
- Fluidized biological reactor;

- Aeration;
- Clarification; and
- Sand filtration.

Chemicals are also added at certain locations within the treatment train to improve efficiencies.

Remedial Alternatives 2b and 2c assume that the pilot study will demonstrate that the ultrafiltration/reverse osmosis/biological fluidized bed bioreactor treatment technology is implementable and effective for the removal of selenium from groundwater discharging at the springs.

Alternative 2c would entail addition of a third treatment train to the system to bring the treatment flow rate to 3,000 gpm. This would be easy to implement by adding an additional ultrafiltration/reverse osmosis/fluidized bed bioreactor treatment train in parallel to the existing system.

In addition to covers and water treatment, access controls and deed restrictions would be implemented to address environmental conditions:

- Access to seep areas LP-1 and DS-7 and detention basins DP-7 and EP-2 would be restricted by fencing (to prevent livestock access) and signs to notify people that drinking the water is potentially unsafe.

- Grazing controls, land-use controls and information programs would be implemented by the Forest Service as needed to restrict access to the cover areas while the cover vegetation matures.

- Simplot would implement deed restrictions on its land in Sage Valley to prevent use of groundwater with arsenic or selenium concentrations above their respective MCLs as a domestic water supply and to prevent use of groundwater with selenium or manganese concentrations above 0.05 mg/L as a stock watering source (in the area of wells GW-17 and GW-25).

5.1.3 Alternative 3 – Barrier Cover + Infiltration-Reduction Cover

Under this alternative, the same cover of a 1-foot-thick chert/limestone capillary break layer overlain by a 1-foot-thick layer of Dinwoody material would be installed at Panel A Area 2.

At Panel D an infiltration-reduction cover would be installed. This cover would be constructed of materials available at the Site (Dinwoody, chert/limestone and possibly tailings) and would be designed to reduce infiltration into the ODA. The performance of different cover systems is being tested at the Site and, as such, no single design is proposed in this document. Examples of potential covers in this category are: the 5-foot thick cover installed on the Pole Canyon ODA in 2015, the deep-Dinwoody cover developed for F Panel reclamation, water balance covers (Albright et al., 2009), and the Dinwoody cover installed on Panel E. Other combinations and depths of materials may be more appropriate (to be determined by field pilot study testing to support remedial design).

Different covers are included at Panel A and at Panel D under this alternative to allow for an assessment of the relative effect of the different covers on selenium loading to the springs complex over time. As shown in Figure 2-6 it is estimated that the selenium loading to the Wells Formation from Panel A and Panel D is of similar magnitude. Because Panel D is closer to the springs complex than Panel A, any source control at Panel D will have a quicker effect on selenium loading at the springs. It is also possible that this cover combination will meet the requirements of the RAOs; to be assessed in the detailed analysis.

The same access restrictions and land use controls as Alternative 2 would be implemented. Also, Alternative 3 contains the same three variants for treatment at the springs complex: 3a no treatment; 3b 2,000 gpm treatment; and 3c 3,000 gpm treatment.

5.1.4 Alternative 4 – Infiltration-Reduction Cover

Under this alternative, infiltration-reduction covers would be installed at both Panel A Area 2 and Panel D. All other elements of the alternative would be the same as Alternative 3, including the treatment variants.

5.1.5 Alternative 5 – Geosynthetic Covers

Under this alternative, geosynthetic covers (i.e., with a GM liner, a GCL, or equivalent) would be installed at Panel A Area 2 and Panel D. All other elements of the alternative would be the same as Alternative 4, including the treatment variants.

5.2 Screening Evaluation of Alternatives

In the screening step, each alternative is evaluated against the short- and long-term aspects (where applicable) of three broad criteria: effectiveness, implementability, and cost. Because the purpose of the screening evaluation is to reduce the number of alternatives that will undergo a more thorough and extensive analysis, alternatives are evaluated more generally in this phase than during the detailed analysis. However, the screening evaluation is sufficiently detailed to distinguish among alternatives.

Under the effectiveness evaluation, each alternative is assessed for its ability to provide protection of human health and the environment and the reductions in toxicity, mobility, or volume it will achieve. Both short- and long-term components of effectiveness are evaluated. Short-term effectiveness refers to the construction and implementation period, and long-term effectiveness refers to the period after the remedial action is complete. A key element in the detailed analysis will be updating the groundwater transport models to reflect latest Site conditions (i.e. the refined understanding of groundwater flow directions and velocities, and performance and monitoring data for the Pole Canyon ODA NTCRA cover and other covers installed for reclamation). This will be coupled with the latest selenium data at the springs complex (to further refine the model calibration) and data on treatment effectiveness from the pilot study. Because all of these inputs will need to be developed for the detailed analysis and some will not be available until 2017 (results from Phase 2 of the fluidized bed bioreactor biological treatment pilot study, for example), only a basic analysis is provided herein. This will be refined in FS Technical Memorandum #2.

Under the implementability evaluation, the technical and administrative feasibility of constructing, operating, and maintaining each alternative is evaluated. Technical feasibility refers to the ability to construct, reliably operate, and meet technology-specific regulations for process options until the remedial action is complete. It also includes O&M, replacement, and monitoring of technical components of an alternative after the action is complete. Administrative feasibility refers to the ability to obtain approvals from other offices and regulatory agencies and the availability of services, capacity, equipment, and technical specialists.

The cost evaluation compares the relative costs of the alternatives. Costs are typically not defined with the level of accuracy desired for the detailed analysis (i.e., +50% to -30%); however, the relative accuracy of the estimates should be consistent so that cost decisions among alternatives will be sustained as the accuracy of cost estimates improves beyond the screening process. The O&M costs are evaluated as present-worth costs, using a 7% discount rate and 30-year performance period, consistent with USEPA guidance (USEPA 2000b).

5.2.1 Alternative 1 - No Further Action

5.2.1.1 Effectiveness

Alternative 1 includes no additional actions to limit exposures of human or ecological receptors to selenium or arsenic in ODA materials, surface water, groundwater, and plants. It would not reduce the magnitude of sources. Alternative 1 would attain none of the RAOs in the foreseeable future.

5.2.1.2 Implementability

Alternative 1 entails continuation of O&M and monitoring activities for the two NTRCAs at the Pole Canyon ODA. These actions are implementable.

5.2.1.3 Cost

Simplot has already expended $3.6 Million on the 2006 NTCRA (NewFields et al. 2009) and $9.9 Million on the 2013 NTCRA at the Pole Canyon ODA. O&M and monitoring activities would continue under this alternative at an approximate cost of $50,000 per year.

5.2.1.4 Screening Assessment

Consideration of the No Further Action alternative is required by the NCP and consequently it is retained for detailed analysis in the FS.

5.2.2 Alternative 2 – Barrier Covers

5.2.2.1 Effectiveness

A field-scale pilot study being performed under CERCLA at the Conda Mine (Formation 2012e, 2016c) indicates that a 1-foot-thick chert/limestone capillary break layer overlain by a 1-foot-thick layer of Dinwoody material would be adequate to achieve the soil and vegetation PRGs. The cover would also prevent direct contact with the overburden and thus eliminate risks due to elevated selenium and arsenic concentrations in this material. The cover would reduce concentrations of arsenic and selenium at the surface and plant uptake of selenium would be reduced such that the average selenium concentration in vegetation would be below 10 mg/kg Sitewide and below 5 mg/Kg in each grazing allotment. Barrier covers would therefore meet the RAOs for protection of livestock and terrestrial biota.

The EE/CA developed for the 2013 NTCRA at Pole Canyon estimated that a Dinwoody/chert cover with 1 foot of Dinwoody material would reduce percolation into the overburden material by 42% (Formation 2012a). Recent and on-going testing of cover systems at Smoky Canyon Mine has indicated that this estimate may be high. An updated estimate will be used in the detailed analysis. On a relative basis (compared to the other cover types being evaluated) the reduction of percolation would be "low". Reduction in percolation for barrier covers at Panel A Area 2 and Panel D would be expected to be in the same range (this will be assessed for these specific areas in the detailed analysis).

Restriction of livestock access to seeps and detention basins would be effective in preventing use as a drinking source. Signage would be effective in notifying people that drinking the water is potentially unsafe. Grazing controls, land-use controls and information programs implemented by the Forest Service would be effective to protect the remedy in the cover areas while the cover vegetation matures. Deed restrictions on Simplot's land in Sage Valley to prevent use of groundwater with arsenic or selenium concentrations above their respective MCLs as a domestic water supply and to prevent use of groundwater with selenium or manganese concentrations above 0.05 mg/L as a stock watering source would be effective in protecting people and livestock.

Selenium concentrations measured in groundwater and surface water during the RI are primarily related to releases during active mining. Concentrations are predicted to be reduced in the future as the post-mining conditions begin to exert a greater effect. Selenium releases from ODAs are predicted to reduce over time (over a period of decades, as shown in Figure 2-6). In addition, improved reclamation activities, the Pole Canyon ODA NTCRAs, and improved Sitewide stormwater controls are predicted to further reduce selenium releases from ODAs in the future. All of these actions will reduce selenium levels in groundwater and eventually in water discharging at the springs complex with additional remedial actions (for example, see Figure 2-6). Additional reductions in selenium loading from Panel A Area 2 and Panel D to groundwater due to the barrier covers would also occur. Groundwater travel times to the springs complex from Panel D and Panel A are of the order of 19 and 24 years on average, respectively. The effect of any cover systems in these areas would take similar times to reduce selenium levels in groundwater discharging at the springs further than the levels shown in Figure 2-6. Addition of treatment at the springs would increase the effectiveness and reduce the time until the surface water RAOs are met.

Passive treatment at the LP-1 and/or the DS-7 seep may be effective in removing selenium from the environment and thus reducing the loading to groundwater in the short term and ultimately to the springs complex. Treatment concepts will be provided and evaluated in the detailed analysis.

A fluidized bed bioreactor has been tested at the springs at a 250 gpm flow rate (Formation 2014d). Total selenium concentrations in the effluent ranged from 0.00527 to 0.0106 (mean of 0.0083 mg/L) and in the influent ranged from 0.113 to 0.138 mg/L (mean of 0.126 mg/L), resulting in an average decrease in selenium concentration of 93 percent (Formation 2016c, Appendix C). The system will be expanded in 2017 to include an ultrafiltration/reverse osmosis pretreatment step, which will increase the treatment capacity of the existing system to 1,000 gpm. In addition, a second identical treatment train will be added to increase the overall system capacity to 2,000 gpm (Formation 2016c).

Reverse osmosis has already been successfully pilot tested at the springs (Formation 2011f). The selenium concentration in the influent water for the pilot study was 0.03 to 0.05 mg/L. Selenium in the “concentrate,” produced by the reverse osmosis unit, ranged from 0.14 to 0.20 mg/L. Selenium concentration in the “permeate” (effluent) from the reverse osmosis unit was effectively non-detect.

The ultrafiltration/reverse osmosis/fluidized bed bioreactor system is therefore expected to be effective, but this needs to be pilot tested. The greater the flow rate of water undergoing treatment (i.e. moving from Alternative 2a to 2c), the greater the reduction of selenium mobility, and the smaller the volume of contaminated surface water released from the springs complex.

5.2.2.2 Implementability

Alternative 2 would be readily implementable. Cover materials are available at the Site and the construction of barrier covers would not require unconventional construction techniques or special access logistics. Simplot has installed similar covers at the Smoky Canyon Mine. Engineering controls are easily implementable during construction activities to prevent impacts to adjoining areas. Based on the preliminary estimate of the Panel A Area 2 and Panel D surface areas (see Table 4-1), it is estimated that approximately 750,000 cubic yards each of Dinwoody and chert/limestone would be required for a 1-foot-thick layer. Dinwoody material is available at the Site (Formation 2016b) and chert/limestone would be generated from ongoing mining at Panel B. Experience with recent reclamation activities at the Smoky Canyon Mine demonstrate that chert/limestone placement can be implemented year-round and that Dinwoody placement can be implemented in the normal spring/summer/fall construction season.

The action would be accomplished using heavy equipment (e.g., scrapers, excavators, dozers, and trucks) provided by Simplot and already present at the mine, or by local contractors. Additionally, trained and experienced labor is available for Site work activities.

Fencing to prevent access to seeps would be implementable. Grazing controls, land use controls and information controls can be implemented by the Forest Service and Simplot can implement deed restrictions on its land.

Semi-passive water treatment systems have been tested at the Site and would be implementable.

Water treatment at the springs complex is implementable. Simplot has already installed and operated a 250 gpm pilot system and is constructing a system to increase the treatment flow to 2,000 gpm (Formation 2016d). Increasing the system to treat 3,000 gpm would be straight forward to achieve by adding another ultrafiltration/reverse osmosis/fluidized bed bioreactor treatment train.

Alternative 2 would be administratively feasible because the Forest Service will coordinate with the other regulatory agencies during the CERCLA process. This alternative would require relatively simple administrative and construction management controls. No offsite permits would be required. Range management and other controls would be implementable because actions are on Forest Service-managed or Simplot-owned land.

5.2.2.3 Cost

Using unit rates for Dinwoody and chert/limestone from the Pole Canyon EE/CA (Formation 2012a) it is estimated that the capital costs for installation of a 1-foot-thick Dinwoody layer over a 1-foot-thick layer of chert/limestone would be $31,000 per acre. Extrapolating for the estimated 460 acres associated with Panel A Area 2 and Panel D, results in a preliminary cost estimate of $14.3 Million for cover installation. This cost estimate will be refined in the detailed analysis based on updated area estimates, the outcome of the Dinwoody evaluation, and the availability of chert/limestone from active mining.

Passive treatment at seeps LP-1 or DS-7 is conceptual. Specific approaches and evaluation will be provided in the detailed analysis. Costs are estimated to range from $0 (if the technology shows low effectiveness) to $1 Million (if the technology is implemented at both seeps).

Costs for fencing, access controls, land-use controls and information controls would be relatively minor compared to the other remedial components.

Simplot estimated the capital cost for the 2,000 gpm pilot treatment system at $18 Million. Scaling up this cost for a 3,000 gpm system results in an estimated capital cost of $24 Million. These numbers will be refined in the detailed analysis based on actual expenditures for the pilot system.

5.2.2.4 Screening Assessment

Alternative 2 has the potential to be protective of human health and the environment. RAOs for surface water would be met sooner by treating more water from the springs complex. Alternative

2 is implementable and would entail a capital cost in the range of $14 – 39 Million (depending on the treatment options). Alternative 2 is retained for detailed analysis in the FS.

5.2.3 Alternative 3 – Barrier Cover + Infiltration-Reduction Cover

5.2.3.1 Effectiveness

The effectiveness of barrier covers is discussed above in Section 5.2.2.1. A field-scale pilot study being performed under CERCLA at the Conda Mine (Formation 2012e, 2016c) indicates that a 1-foot-thick chert/limestone capillary break layer overlain by a 1-foot-thick layer of Dinwoody material would be adequate to achieve the soil and vegetation PRGs. The covers would also prevent direct contact with the overburden and thus prevent risks due to elevated selenium and arsenic concentrations in this material. Infiltration-reduction covers, which are thicker, would therefore meet the RAOs for protection of livestock and terrestrial biota on ODAs.

Restriction of livestock access to seeps and detention basins would be effective in preventing use as a drinking source. Signage would be effective in notifying people that drinking the water is potentially unsafe. Grazing controls, land-use controls and information programs implemented by the Forest Service would be effective to protect the remedy in the cover areas while the cover vegetation matures. Deed restrictions on Simplot's land in Sage Valley to prevent use of groundwater with arsenic or selenium concentrations above their respective MCLs as a domestic water supply and to prevent use of groundwater with selenium or manganese concentrations above 0.05 mg/L as a stock watering source would be effective in protecting people and livestock.

The infiltration-reduction cover would be designed to reduce infiltration and be constructed of materials available at the Site (i.e., Dinwoody, chert/limestone, and tailings). The 5-foot-thick cover installed on the Pole Canyon ODA in 2015 is an example of this type of cover. The deep-Dinwoody cover developed for Panel F reclamation is another example. Other combinations may be more appropriate including the possibility of using tailings as a subsurface low-permeability barrier (to be determined by field pilot study testing to support remedial design). Infiltration-reduction covers are being tested at the Site. On a relative basis (compared to the other cover types being evaluated) the reduction of percolation would be "moderate".

Selenium concentrations would be expected to be reduced in groundwater and surface water due to installation of the covers at Panel A Area 2 and Panel D (and other measures already implemented as discussed in Section 5.2.2.1). Groundwater travel times to the springs complex from Panel A and Panel D are of the order of 24 and 19 years on average, respectively. The effect of any cover systems in these areas would take similar times to reduce selenium levels in groundwater discharging at the springs.

Addition of treatment at the springs would increase the effectiveness and reduce the time until the surface water RAOs are met. The greater the flow rate of water undergoing treatment (i.e. moving from Alternative 3a to 3c), the greater the reduction of selenium mobility, and the smaller the volume of contaminated surface water released from the springs complex.

5.2.3.2 Implementability

Alternative 3 would be readily implementable. It would not require unconventional construction techniques or special access logistics. Simplot has installed similar covers at the Smoky Canyon Mine. Engineering controls are easily implementable during construction activities to prevent impacts to adjoining areas. Based on the preliminary estimate of the ODA surface areas (see Table 4-1), and assuming that the infiltration-reduction cover on Panel D would consist of 3 feet of Dinwoody and 2 feet of chert/limestone (i.e., consistent with the Pole Canyon cover), it is estimated that approximately 1.6 million cubic yards of Dinwoody and 1.2 million cubic yards of chert/limestone would be required for the covers on Panel A Area 2 and Panel D. Dinwoody is available at the Site (Formation 2016b). Chert/limestone would be generated from ongoing mining at Panel B. If tailings material is used, there are sufficient volumes available in the tailings ponds for cover construction.

The action would be accomplished using heavy equipment (e.g., scrapers, excavators, dozers, and trucks) provided by Simplot and already present at the mine, or by local contractors. Additionally, trained and experienced labor is available for Site work activities.

Fencing to prevent access to seeps would be implementable. Grazing controls, land use controls and information controls can be implemented by the Forest Service and Simplot can implement deed restrictions on its land.

Alternative 3 would be administratively feasible because the Forest Service will coordinate with the other regulatory agencies during the CERCLA process. Alternative 3 would require relatively simple administrative and construction management controls. No offsite permits would be required. Range management and other controls would be implementable because actions are on Forest Service-managed or Simplot-owned land.

5.2.3.3 Cost

As described in Section 5.2.2.3, the capital cost for installation of a 1-foot-thick Dinwoody layer over a 1-foot-thick layer of chert/limestone is $31,000 per acre. For the 190 acres at Panel A Area 2, this would be $5.9 Million. For a 3-foot-thick Dinwoody layer over a 2-foot-thick layer of chert/limestone the actual construction cost was $72,000 per acre. For the 270 acres at Panel D, this would extrapolate to a cost of $19.5 Million. The total capital cost to install covers under Alternative 3 is therefore $25 Million. This estimate will be refined in the detailed analysis based on updated area estimates, the outcome of the Dinwoody evaluation, and the availability of chert/limestone from active mining.

Costs for fencing, access controls, land-use controls and information controls would be relatively minor compared to the other remedial components.

Simplot estimated the capital cost for the 2,000 gpm pilot treatment system at $18 Million. Scaling up this cost for a 3,000 gpm system results in an estimated capital cost of $24 Million. These numbers will be refined in the detailed analysis based on actual expenditures for the pilot system.

5.2.3.4 Screening Assessment

Alternative 3 has the potential to be protective of human health and the environment. The greater the treatment flow at the springs complex (i.e., moving from Alternative 3a to 3c) the sooner RAOs for surface water would be met. Alternative 3 is implementable and would entail a capital cost in the range of $25 - 49 Million (depending on the treatment option). Alternative 3 is retained for detailed analysis in the FS.

5.2.4 Alternative 4 – Infiltration-Reduction Covers

5.2.4.1 Effectiveness

The effectiveness of infiltration-reduction covers is discussed above in Section 5.2.3.1. A field-scale pilot study being performed under CERCLA at the Conda Mine (Formation 2012e, 2016c) indicates that a 1-foot-thick chert/limestone capillary break layer overlain by a 1-foot-thick layer of Dinwoody material would be adequate to achieve the soil and vegetation PRGs. Infiltration-reduction covers, which are thicker, would therefore meet the RAOs for protection of livestock and terrestrial biota on ODAs. The covers would also prevent direct contact with the overburden and thus prevent risks due to elevated selenium and arsenic concentrations in this material.

Restriction of livestock access to seeps and detention basins would be effective in preventing use as a drinking source. Signage would be effective in notifying people that drinking the water is potentially unsafe. Grazing controls, land-use controls and information programs implemented by the Forest Service would be effective to protect the remedy in the cover areas while the cover vegetation matures. Deed restrictions on Simplot's land in Sage Valley to prevent use of groundwater with arsenic or selenium concentrations above their respective MCLs as a domestic water supply and to prevent use of groundwater with selenium or manganese concentrations above 0.05 mg/L as a stock watering source would be effective in protecting people and livestock.

The effectiveness of infiltration-reduction covers are discussed above in Section 5.2.3.1. The infiltration-cover would be designed to reduce infiltration and be constructed of materials available at the Site (i.e., Dinwoody, chert/limestone and tailings). The 5-foot-thick cover installed on the Pole Canyon ODA in 2015 is an example of this type of cover. The deep-Dinwoody cover developed for Panel F reclamation is another example. Other combinations may be more appropriate including the possibility of using tailings as a subsurface low-permeability barrier (to be determined by field pilot study testing to support remedial design). On a relative basis (compared to the other cover types being evaluated) the reduction of percolation would be “moderate”.

Selenium concentrations would be expected to be reduced in groundwater and surface water due to installation of the covers (and other measures already implemented as discussed in Section 5.2.2.1). Addition of treatment at the springs would increase the effectiveness and reduce the time until the surface water RAOs are met.

5.2.4.2 Implementability

Alternative 4 would be readily implementable. It would not require unconventional construction techniques or special access logistics. Simplot has installed similar covers at the Smoky Canyon Mine. Dinwoody is available at the Site (Formation 2016b). Chert/limestone would be generated from ongoing mining at Panel B. If tailings are used, there are sufficient volumes available in the tailings ponds for cover construction.

The action would be accomplished using heavy equipment (e.g., scrapers, excavators, dozers, and trucks) provided by Simplot and already present at the mine, or by local contractors. Additionally, trained and experienced labor is available for Site work activities.

Fencing to prevent access to seeps would be implementable. Grazing controls, land use controls and information controls can be implemented by the Forest Service and Simplot can implement deed restrictions on its land.

Alternative 4 would be administratively feasible because the Forest Service will coordinate with the other regulatory agencies during the CERCLA process. Alternative 4 would require relatively simple administrative and construction management controls. No offsite permits would be required. Range management and other controls would be implementable because actions are on Forest Service-managed or Simplot-owned land.

5.2.4.3 Cost

As an example, the Pole Canyon 2015 NTCRA capital costs were $72,000 per acre (for 139 acres). Extrapolating for the estimated 460 acres associated with Panel A Area 2 and Panel D results in a preliminary capital cost estimate of $33 Million for cover installation. This cost will be refined in the detailed analysis based on updated area estimates, the outcome of the Dinwoody evaluation, and the availability of chert/limestone from active mining.

Costs for fencing, access controls, land-use controls and information controls would be relatively minor compared to the other remedial components.

Simplot estimated the capital cost for the 2,000 gpm pilot treatment system at $18 Million (Formation 2014a). Scaling up this cost for a 3,000 gpm system results in an estimated capital cost of $24 Million. These numbers will be refined in the detailed analysis based on actual expenditures for the pilot system.

5.2.4.4 Screening Assessment

Alternative 4 has the potential to be protective of human health and the environment. RAOs for surface water would be met sooner by treating more water from the springs complex. Alternative 4 is implementable and would entail a capital cost in the range of $33 - 57 Million (depending on the treatment option). Alternative 4 is retained for detailed analysis in the FS.

5.2.5 Alternative 5 – Geosynthetic Covers

5.2.5.1 Effectiveness

The effectiveness of infiltration-reduction covers is discussed above in Section 5.2.3.1. A field-scale pilot study being performed under CERCLA at the Conda Mine (Formation 2012e, 2016c) indicates that a 1-foot-thick chert/limestone capillary break layer overlain by a 1-foot-thick layer of Dinwoody material would be adequate to achieve the soil and vegetation PRGs. Geosynthetic covers, which contain impermeable barriers, would therefore meet the RAOs for protection of livestock and terrestrial biota on ODAs. The covers would also prevent direct contact with the overburden and thus prevent risks due to elevated selenium and arsenic concentrations in this material.

Restriction of livestock access to seeps and detention basins would be effective in preventing use as a drinking source. Signage would be effective in notifying people that drinking the water is potentially unsafe. Grazing controls, land-use controls and information programs implemented by the Forest Service would be effective to protect the remedy in the cover areas while the cover vegetation matures. Deed restrictions on Simplot's land in Sage Valley to prevent use of groundwater with arsenic or selenium concentrations above their respective MCLs as a domestic water supply and to prevent use of groundwater with selenium or manganese concentrations above 0.05 mg/L as a stock watering source would be effective in protecting people and livestock.

Geosynthetic covers would reduce infiltration into ODA materials by 97% or more. On a relative basis (compared to the other cover types being evaluated) the reduction of percolation would be "high". This would have a significant effect on selenium concentrations in groundwater and surface water, such that protection of human health and the environment would be expected to be achieved. Addition of treatment at the springs would reduce the time until the surface water RAOs are met.

5.2.5.2 Implementability

Alternative 5 would be implementable. It would not require unconventional construction techniques or special access logistics. Similar covers have been (or are being) installed at other phosphate mines in the area (BLM 2011, USFS 2012). Geosynthetic liner systems are significantly more complicated and time consuming to construct than earthen cover systems. Quality assurance/quality control (QA/QC) requirements and weather restrictions consume at least half of the available construction days during an already short high mountain construction season. Cover materials must be placed uphill or from the side with small, low-ground pressure dozers, which slows the construction process down and adds significant cost to the cover system. Most synthetic liner systems require more layers to be completed, which also inserts more construction time into the process. The synthetic liner must be welded together which is a slow process. Ultimately it takes at least twice as much time to complete a synthetic cover, as compared to an earthen cover. For this reason, many construction seasons would be required to complete a synthetic cover.

Dinwoody and chert/limestone material would be used in the cover system to provide stability, drainage and growth medium for vegetation. Dinwoody is available at the Site (Formation 2016b). Chert/limestone would be generated from ongoing mining at Panel B. A material balance calculation would be required to determine if adequate amounts of suitable materials would be available as they are also utilized in the active mine cover materials.

The action would be accomplished using heavy equipment (e.g., scrapers, excavators, dozers, and trucks) provided by Simplot and already present at the mine, or by local contractors. Additionally, trained and experienced labor is available for Site work activities.

Fencing to prevent access to seeps would be implementable. Grazing controls, land use controls and information controls can be implemented by the Forest Service and Simplot can implement deed restrictions on its land.

Alternative 5 would be administratively feasible because the Forest Service will coordinate with the other regulatory agencies during the CERCLA process. Alternative 5 would require relatively simple administrative and construction management controls. No offsite permits would be required. Range management and other controls would be implementable because actions are on Forest Service-managed or Simplot-owned land.

5.2.5.3 Cost

As an example, the Pole Canyon EE/CA (Formation 2012a) estimated capital costs for installation of a GCL cover at $15.9 million for 120 acres ($132,000 per acre). Experience at other sites (South Maybe Canyon, Blackfoot Bridge Mine) has found that actual costs are much higher (in the range of $175,000 to $200,000 per acre). Extrapolating the Pole Canyon EE/CA estimate for the estimated 460 acres associated with Panel A Area 2 and Panel D, results in a preliminary capital cost estimate of $61 Million for cover installation. This will be refined in the detailed analysis based on updated area estimates, and more detailed cost estimating using Site-specific information and costs from similar projects at other Sites.

Costs for fencing, access controls, land-use controls and information controls would be relatively minor compared to the other remedial components.

Simplot estimated the capital cost for the 2,000 gpm pilot treatment system at $18 Million. Scaling up this cost for a 3,000 gpm system results in a capital cost estimate of $24 Million. These numbers will be refined in the detailed analysis based on actual expenditures for the pilot system.

5.2.5.4 Screening Assessment

Alternative 5 has the potential to be protective of human health and the environment. RAOs for surface water would be met sooner by treating more water from the springs complex. Alternative 5 is implementable and would entail a capital cost in the range of $61 - 85 Million (depending on the treatment option). Alternative 5 is retained for detailed analysis in the FS.

5.3 Summary of Alternative Screening

All of the candidate alternatives are retained for detailed analysis. They all have the potential to improve conditions at the Site and could provide protection of human health and the environment.

As described in Section 5.2, a key element in the detailed analysis will be updating the groundwater transport models to reflect latest Site conditions (i.e. refined understanding of groundwater flow directions and velocities, and performance and monitoring data for the Pole Canyon ODA NTCRA cover and other covers installed for reclamation). This will be coupled with the latest selenium data at the springs complex (to further refine the model calibration) and data on treatment effectiveness from the pilot study. Because all of these inputs will need to be developed for the detailed analysis and some will not be available until 2017 (pilot treatment results for the 2,000 gpm system, for example), a detailed assessment of whether each alternative will meet RAOs, how, and in what time frame is not possible at this time. Therefore, it is appropriate to retain the full range of the candidate alternatives to allow their detailed analysis in FS Technical Memorandum #2.

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TABLES

FIGURES

APPENDIX A

Preliminary Remediation Goals for Soil and Vegetation